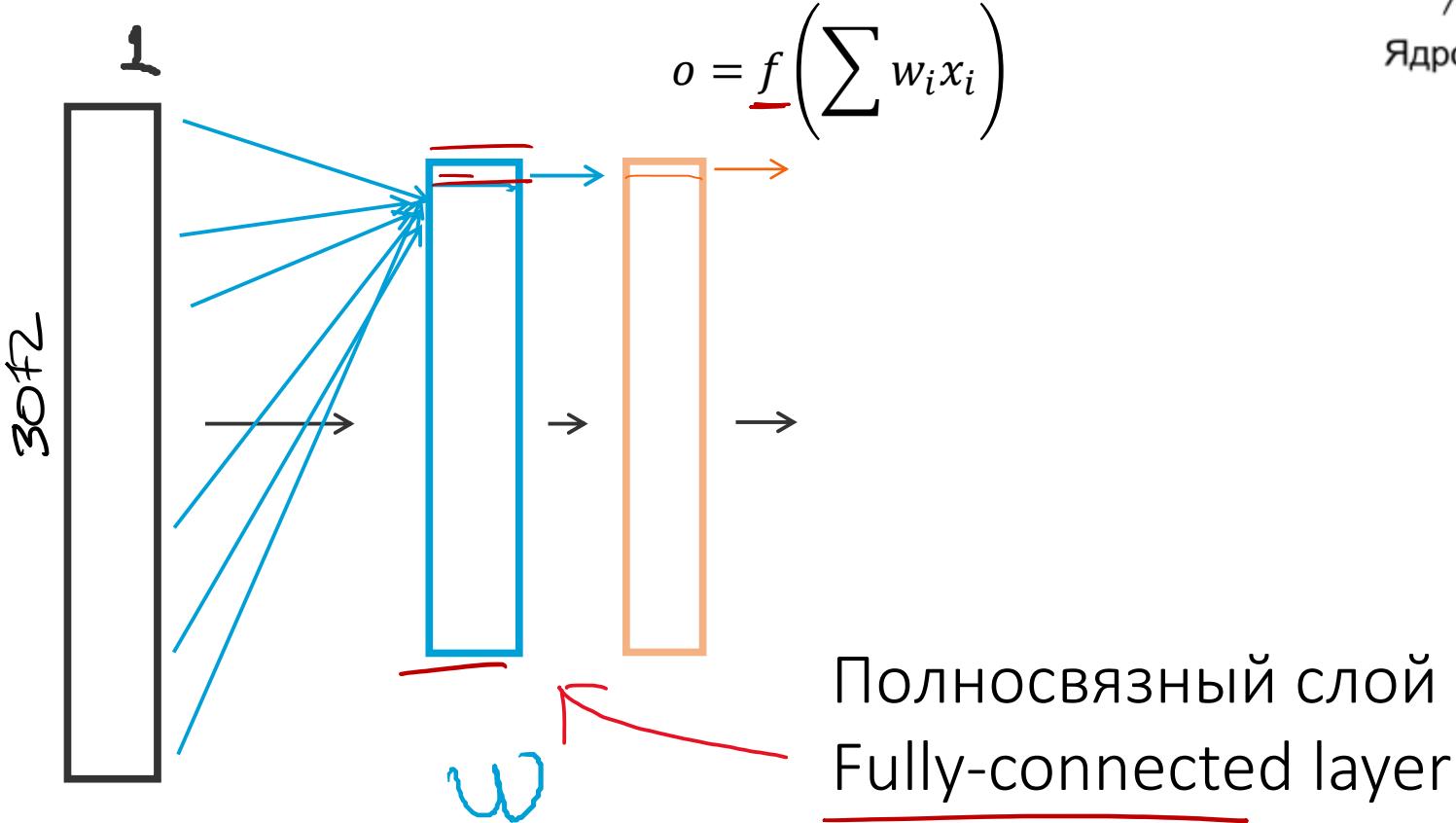




Нейронная сеть

Neural network



Типичная структура нейрона

Дендрит

Ядро

Клеточное тело

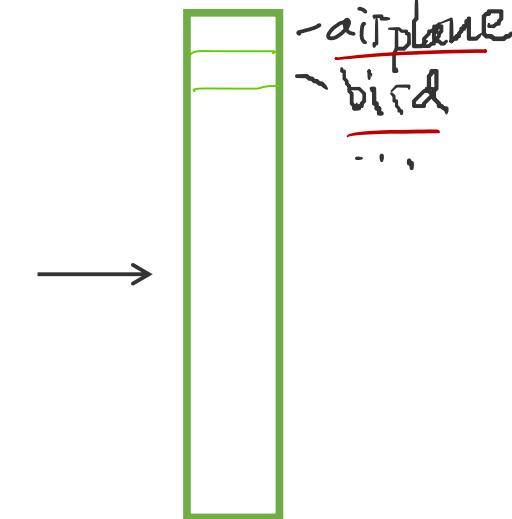
Перехват Ранвье

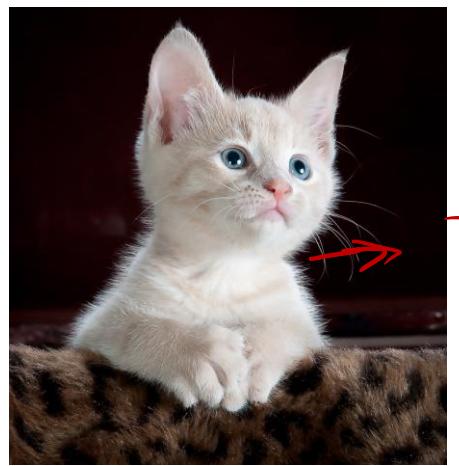
Аксон

Миелиновая оболочка

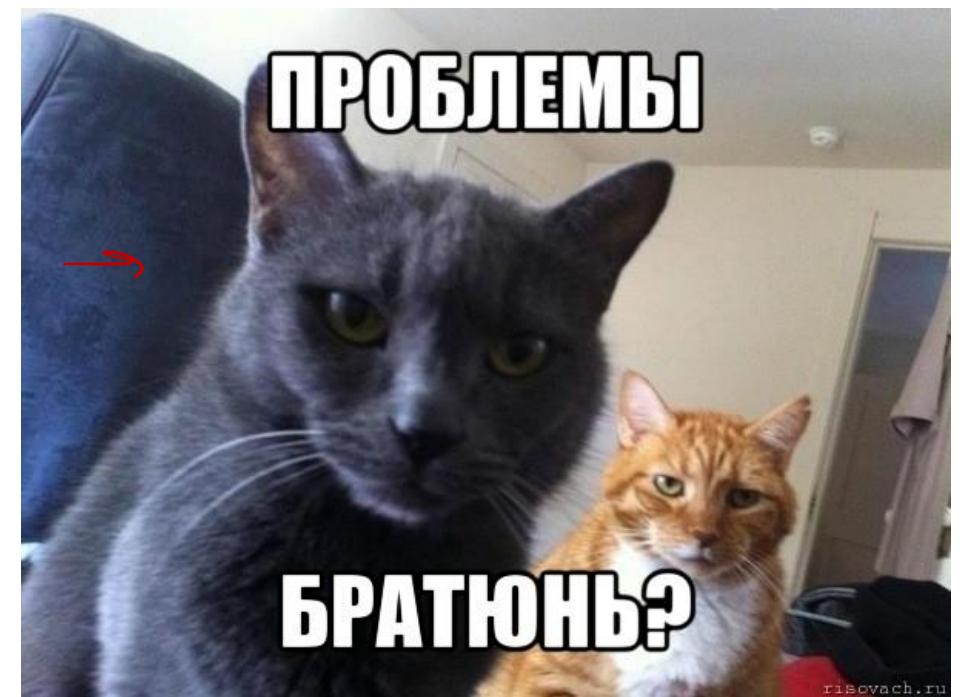
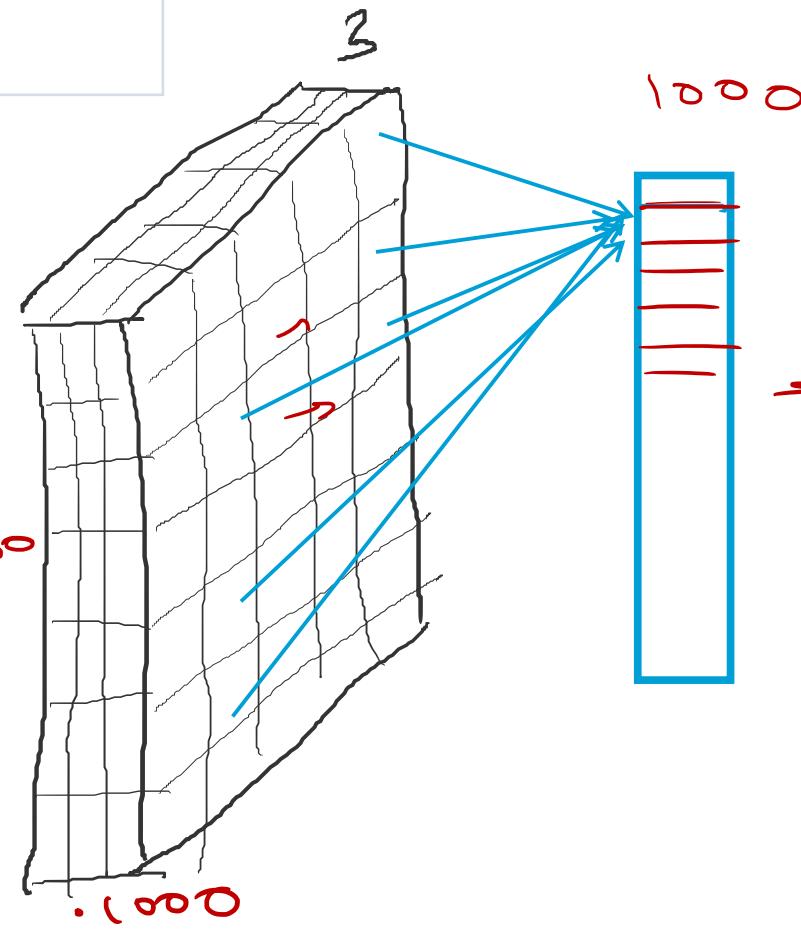
Концевая ветвь
(терминал) аксона

[Wikipedia](#)

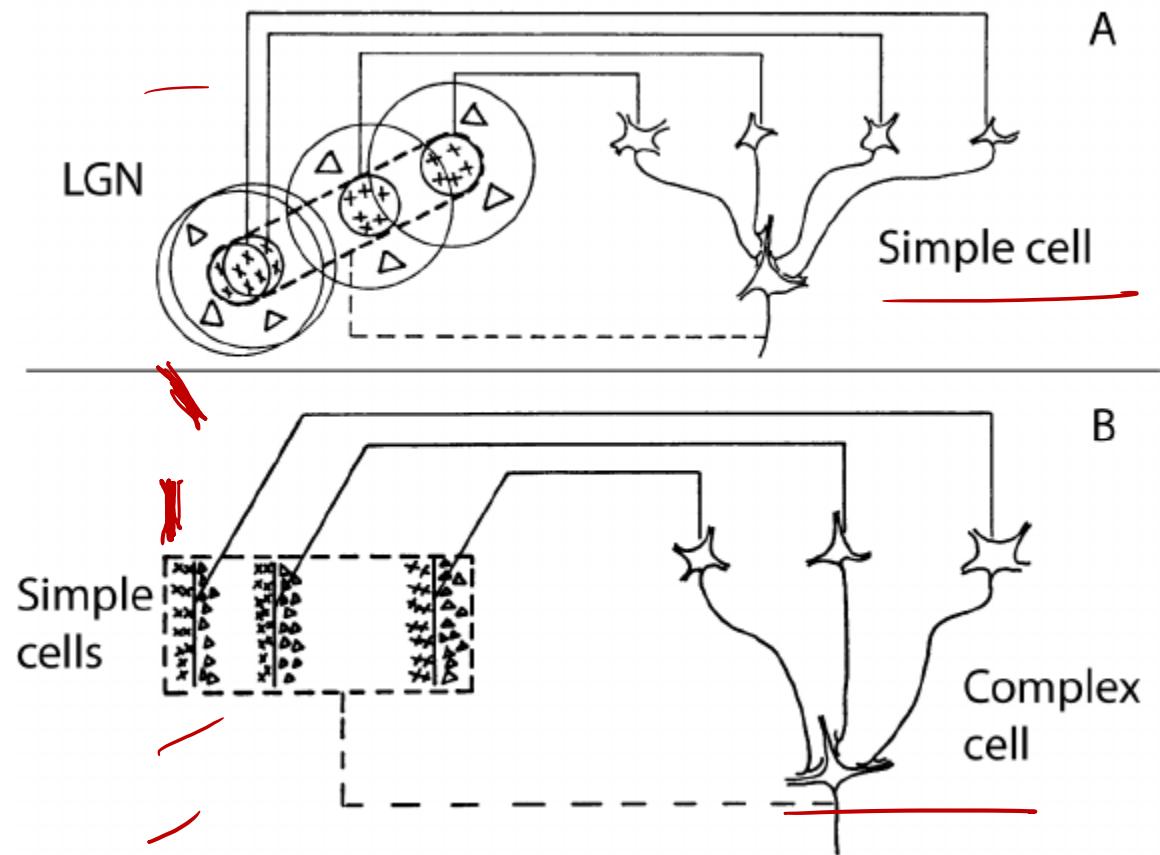
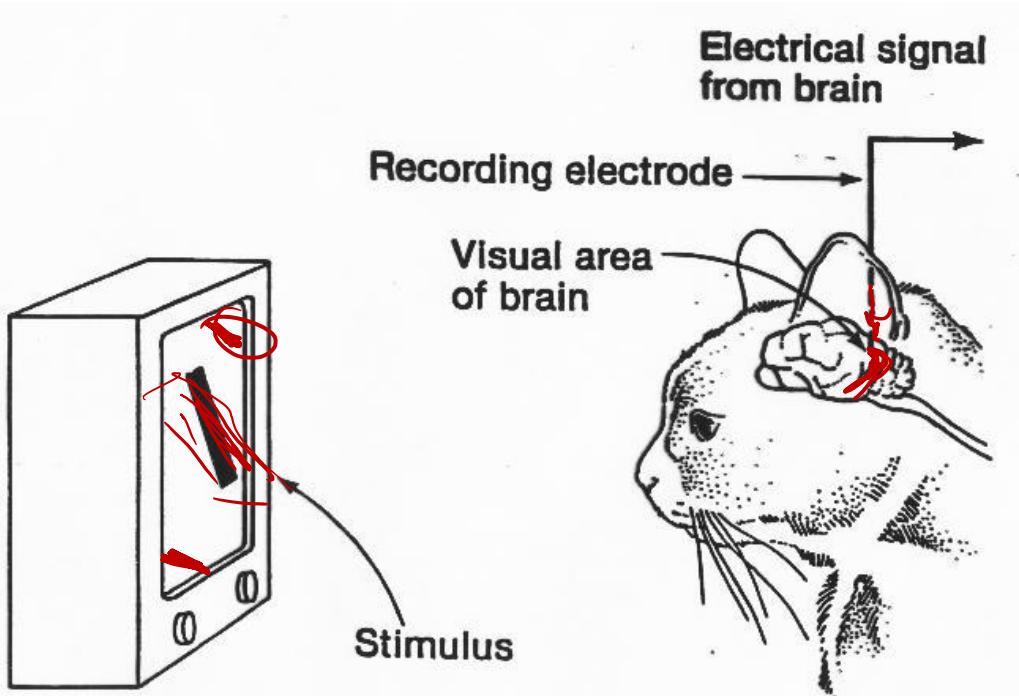




200 · 200 · 3



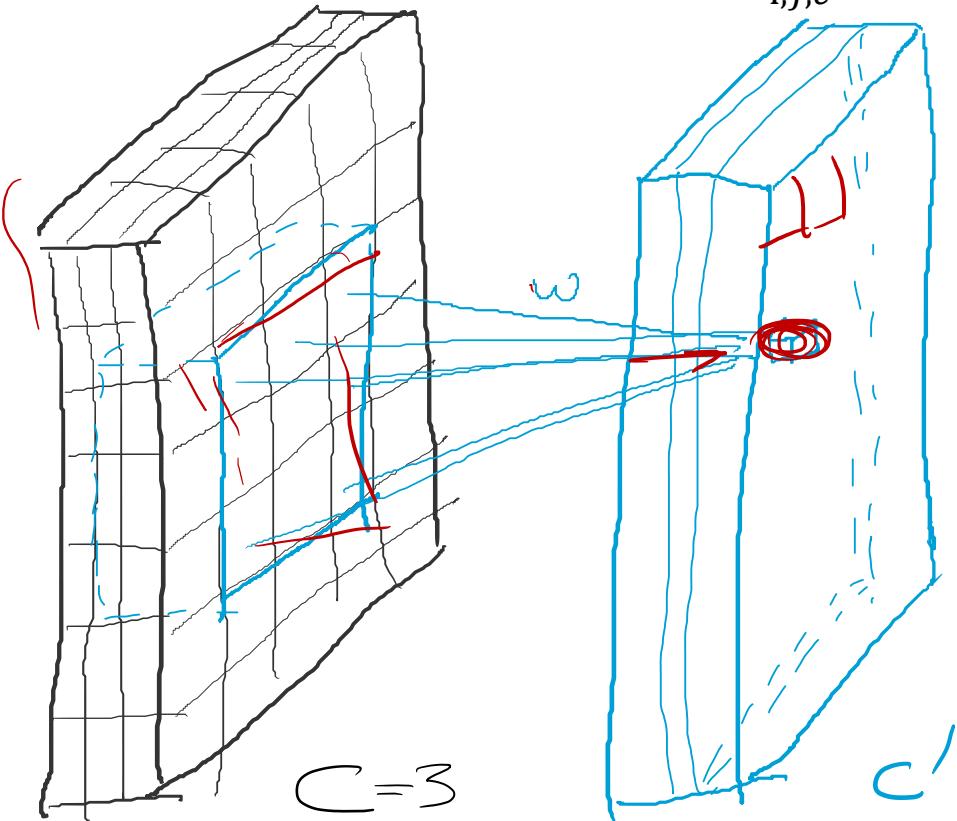
Эксперименты на кошках (в буквальном смысле)

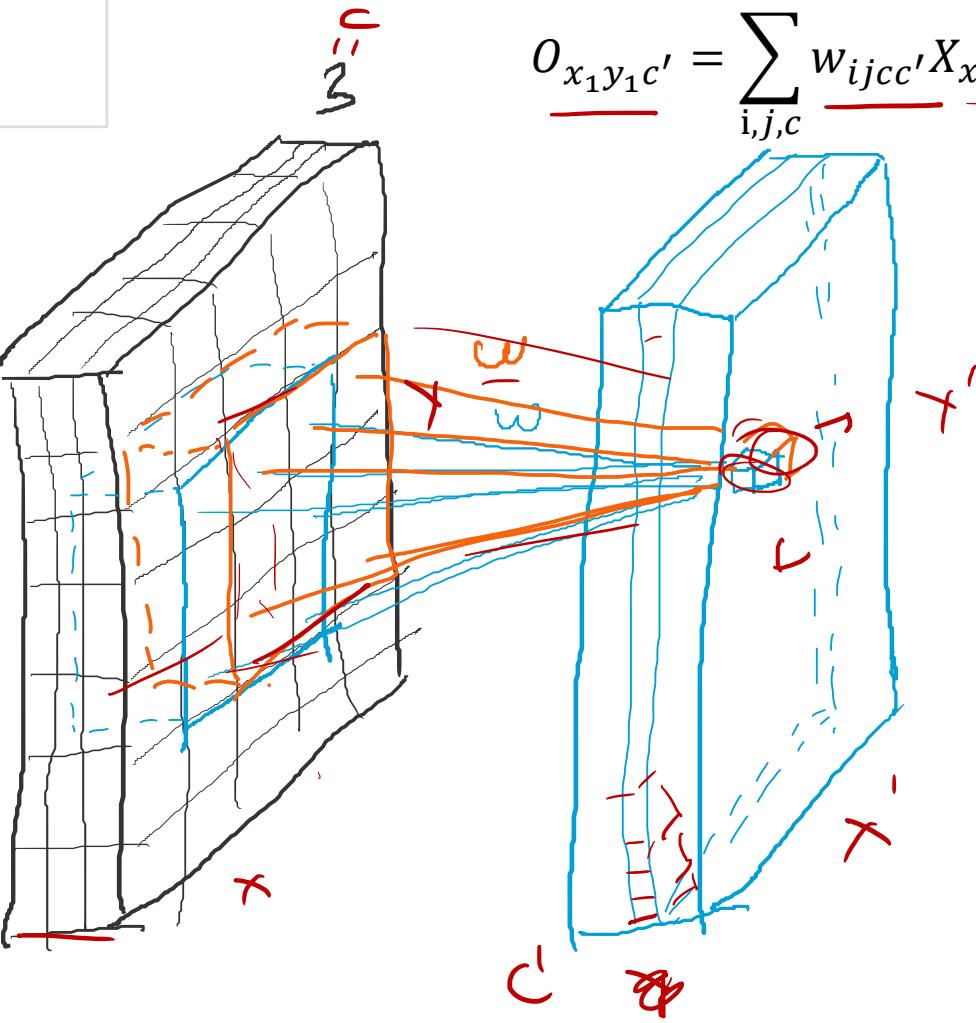
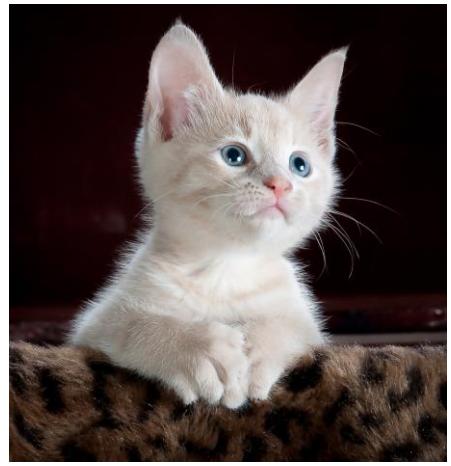


Сверточный слой

Convolution layer

$$O_{xyc'} = \sum_{i,j,c} w_{ijcc'} X_{x-i,y-j,c}$$

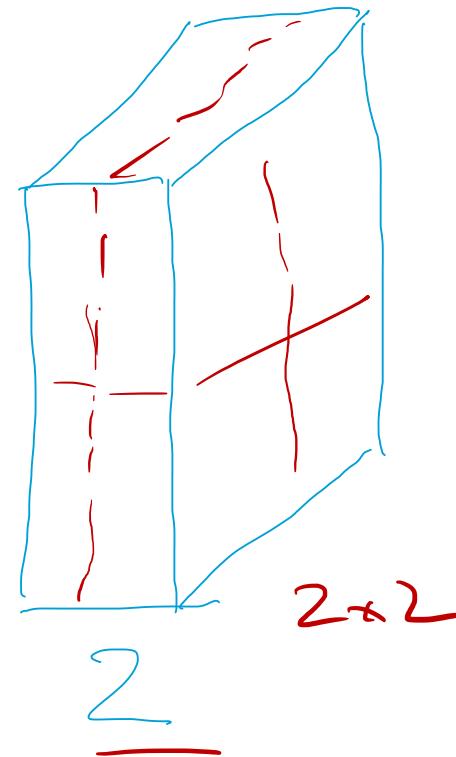
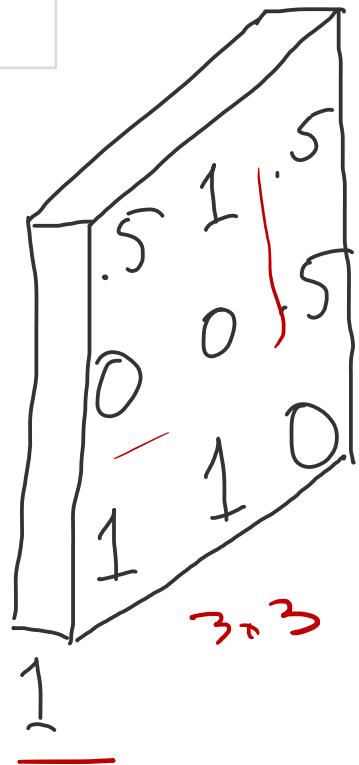
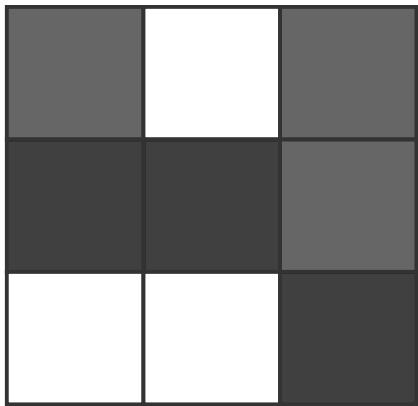




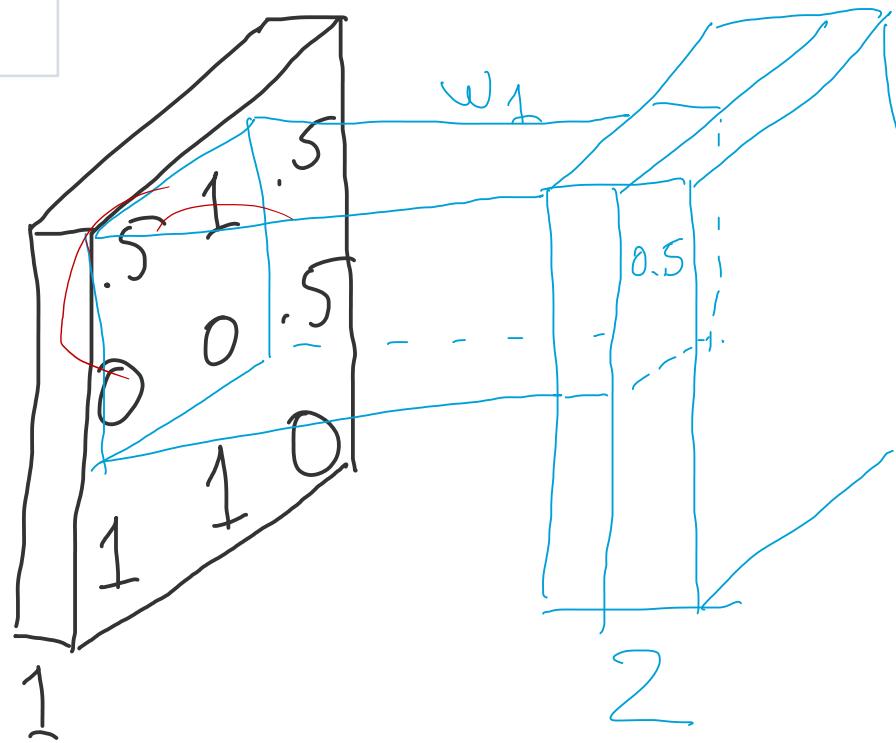
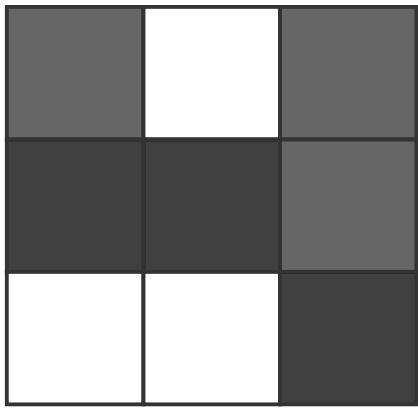
$$O_{xyc'} = \sum_{i,j,c} w_{ijcc'} X_{x-i,y-j,c}$$

$$\begin{aligned} z &= i_j + 1 \\ z' &= i_j + 1 \end{aligned}$$

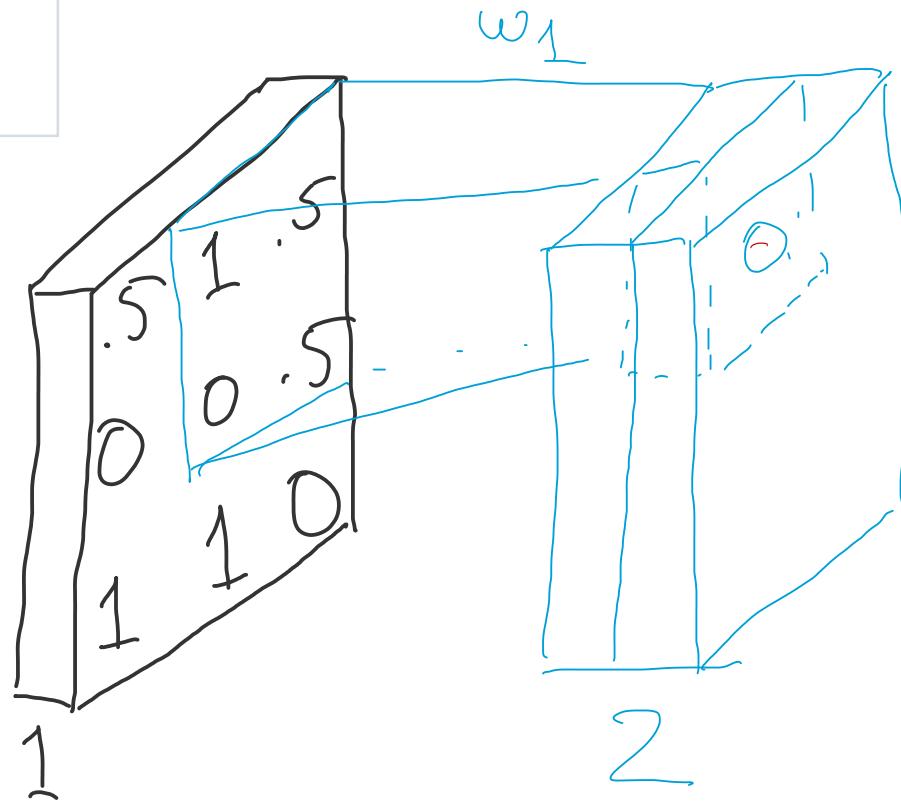
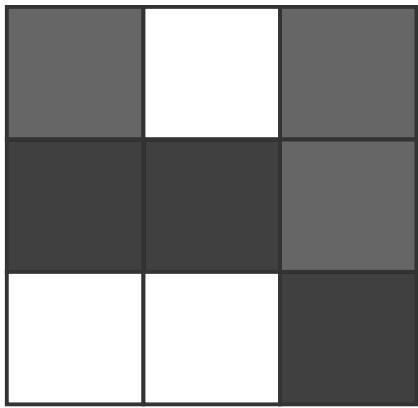
$$O_{x_1y_1c'} = \sum_{i,j,c} w_{ijcc'} X_{x_1-i,y_1-j,c}$$



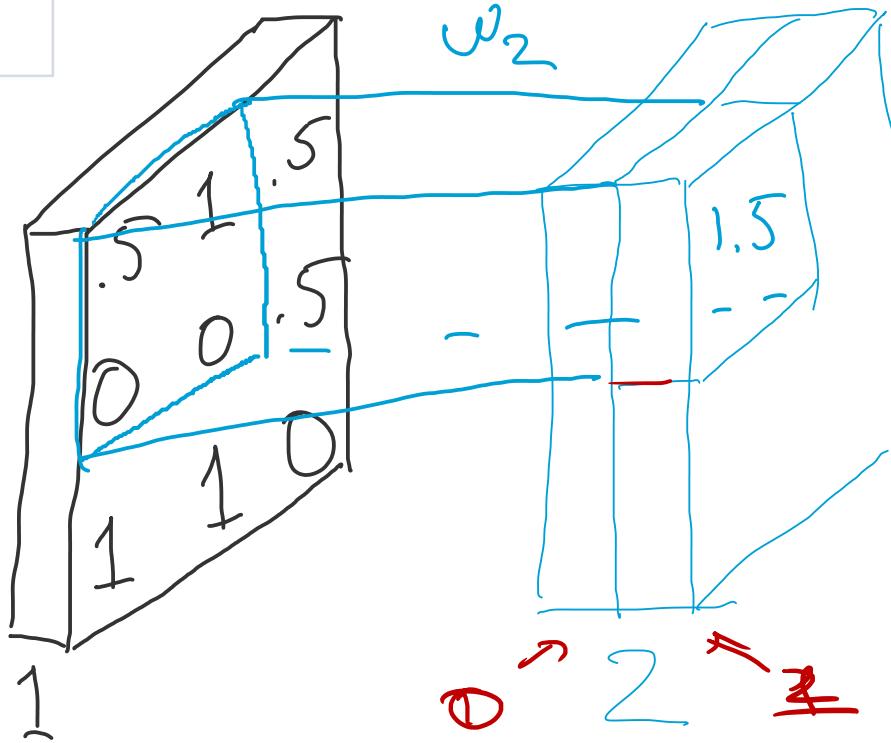
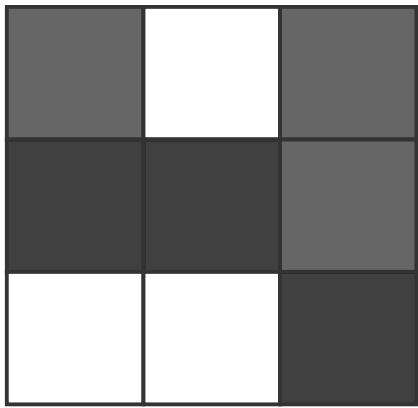
$$\underline{w_{c'=1}} = \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix} \quad \underline{w_{c'=2}} = \begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$$



$$w_{c'=1} = \begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix} \quad w_{c'=2} = \begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$$



$$w_{c'=1} = \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix} \quad w_{c'=2} = \begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$$



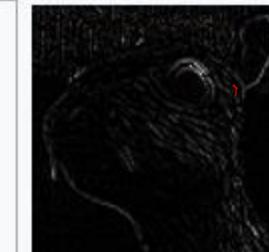
$$w_{c'=0} = \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix} \quad w_{c'=1} = \begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$$

Эквивалентно операции свертки Convolution

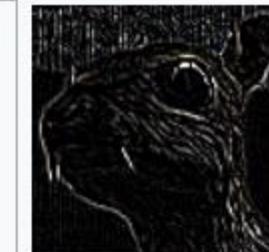


Edge detection

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$



$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$



Sharpen

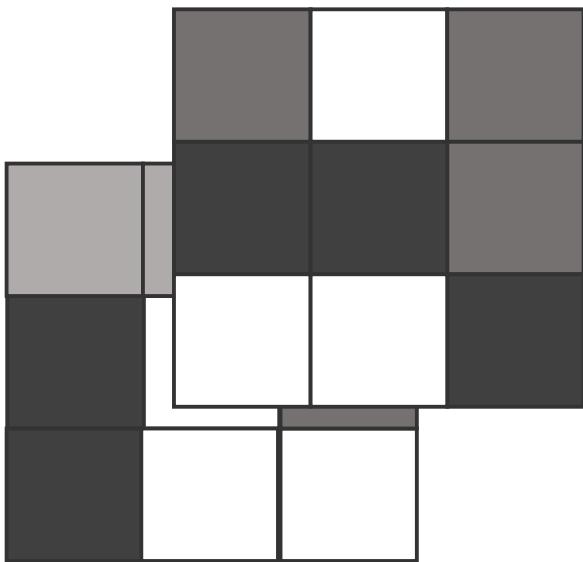
$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$



Box blur
(normalized)

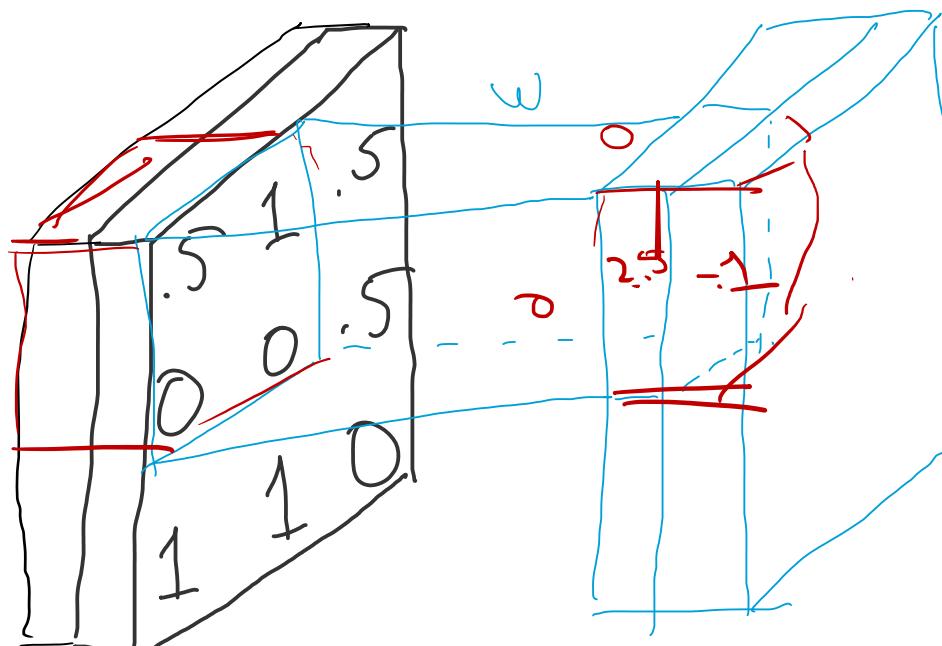
$$\frac{1}{9} \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$





$$in_{ijc} = \left[\begin{bmatrix} 0.5 & 0.5 \\ 0.5 & 1 \end{bmatrix}, \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix} \right] \Rightarrow [0.5 \ 0.5 \ 0.5 \ 1 \ 0 \ 0 \ 1 \ 0]$$

~~2x2x2~~ ~~8 1x8~~

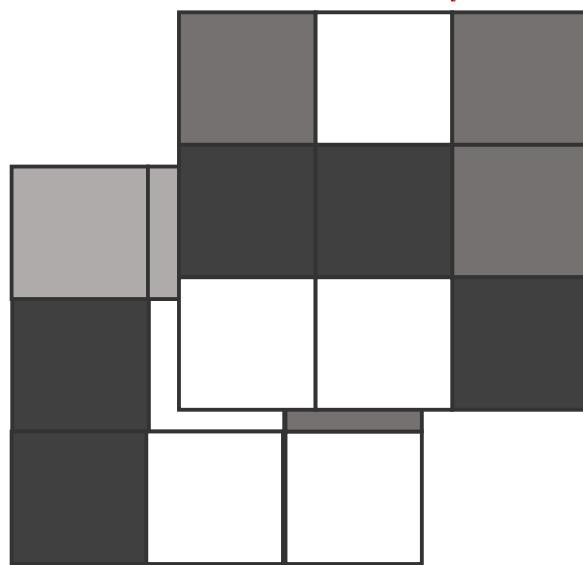


$$w_{ijcc'} = \left[\begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix}, \begin{bmatrix} 2 & -1 \\ 0 & -1 \end{bmatrix}, \begin{bmatrix} 0 & 2 \\ 1 & 1 \end{bmatrix}, \begin{bmatrix} 0 & 1 \\ 0 & 1 \end{bmatrix} \right] \Rightarrow$$

~~2x2x2~~

$$\begin{bmatrix} -1 & 1 \\ 1 & 0 \\ 1 & 1 \\ 1 & -2 \\ -1 & -1 \\ -1 & 0 \\ 1 & 0 \\ -1 & -2 \end{bmatrix}$$

$$\begin{bmatrix} 2.5 & -1 \end{bmatrix}$$

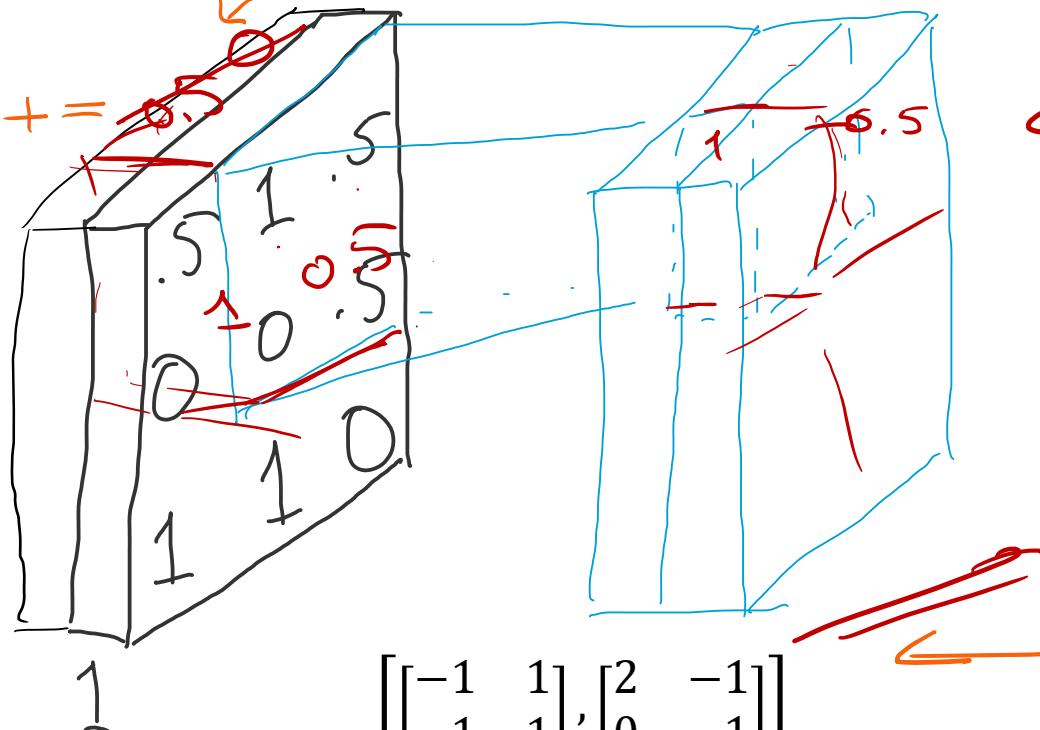


in.grad +

$$w_{ijcc'} = \begin{bmatrix} [-1, 1], [2, -1] \\ [-1, 1], [0, -1] \\ [0, 2], [0, 1] \\ [1, 1], [0, 1] \end{bmatrix} \Rightarrow$$

$\delta_{*2} \leftarrow \underbrace{2*2*2*2}_{\text{2x2x2x2}}$

w.grad + []



$$in_{ijc} = \begin{bmatrix} [0.5, 1], [1, 0] \\ [1, 0.5], [0.5, 0.5] \end{bmatrix} \Rightarrow [0.5, 1, 1, 0.5, 1, 0, 0.5, 0.5]$$

w

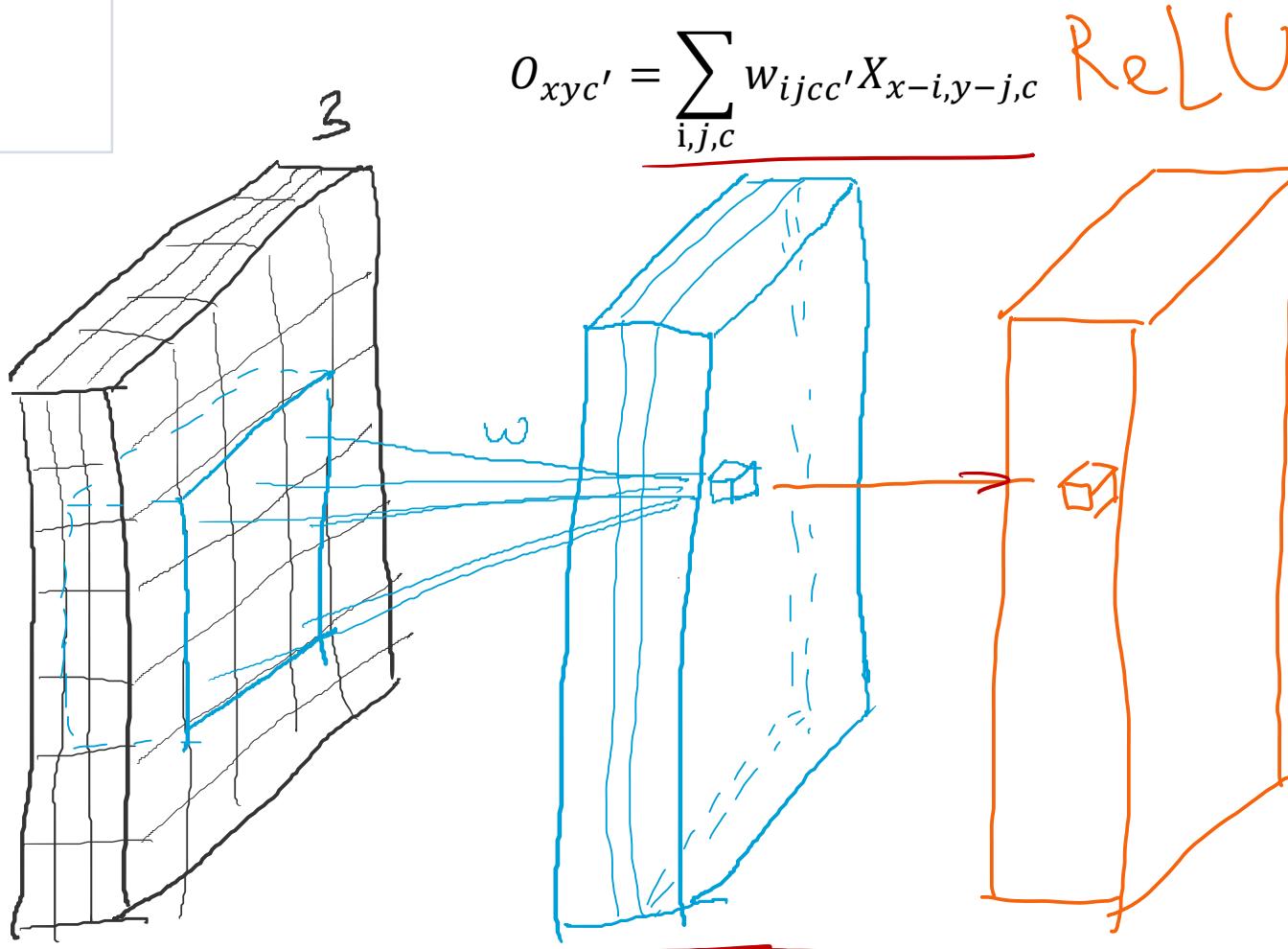
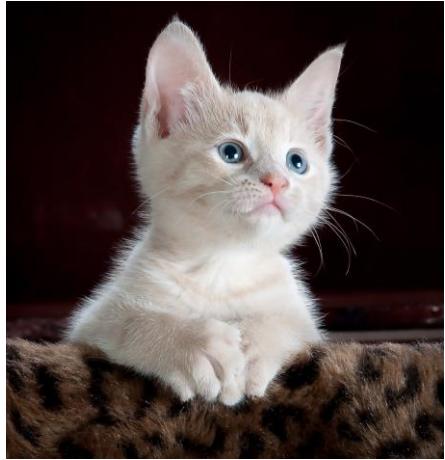
unia

$$\begin{bmatrix} -1 & 1 \\ 1 & 0 \\ 1 & 1 \\ 1 & -2 \\ -1 & -1 \\ -1 & 0 \\ 1 & 0 \\ -1 & -2 \end{bmatrix}$$

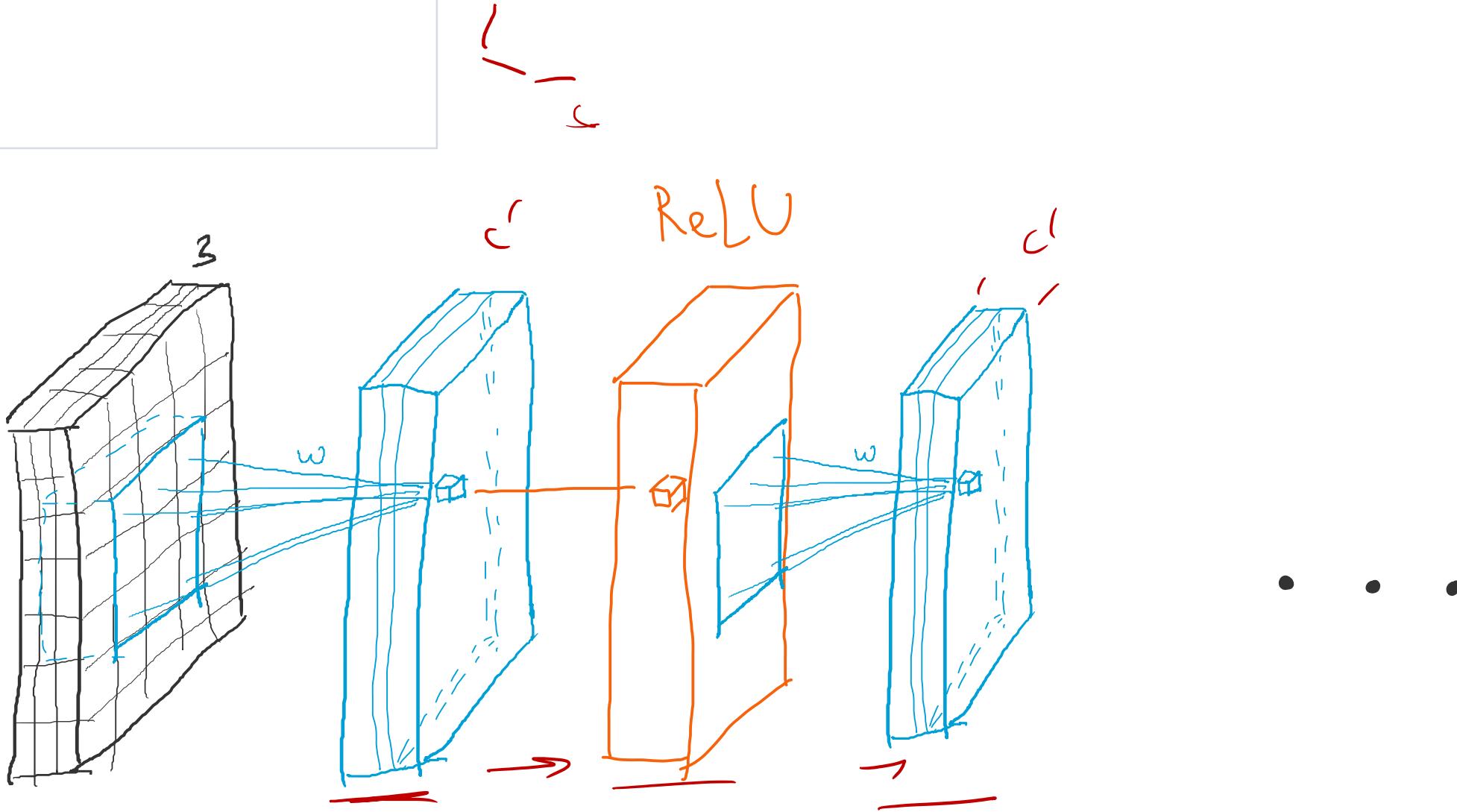
ω

[1 -0.5] grad

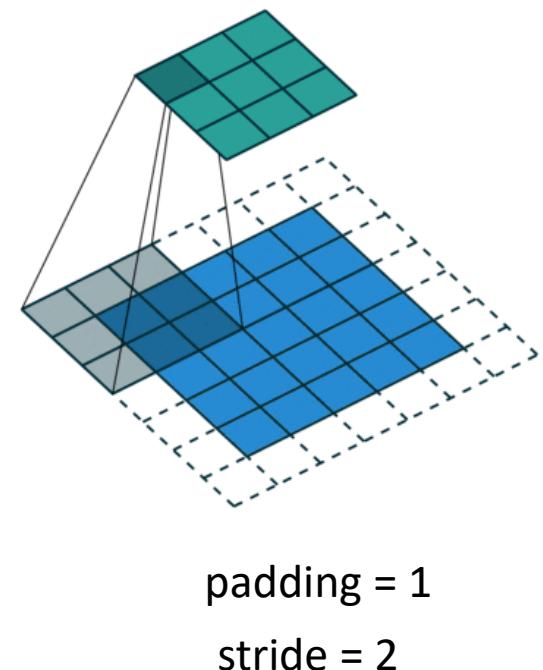
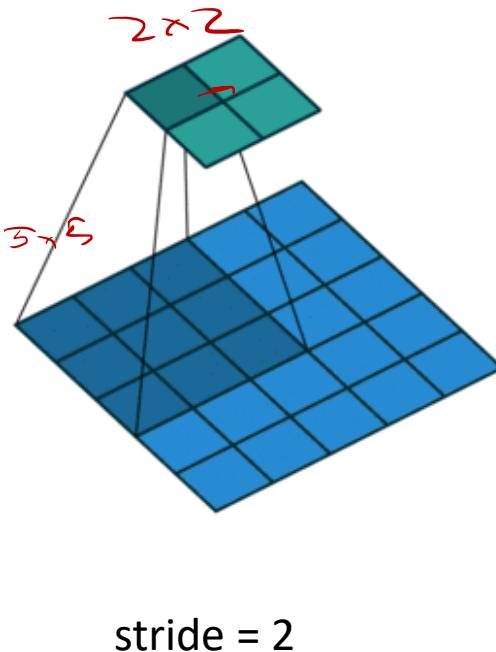
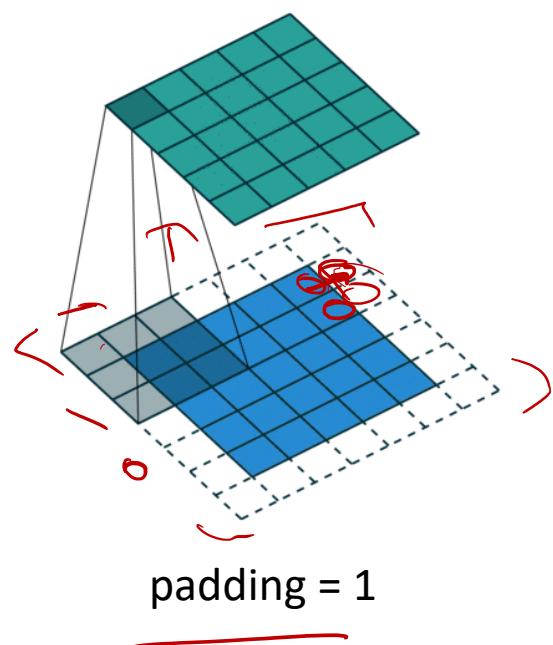
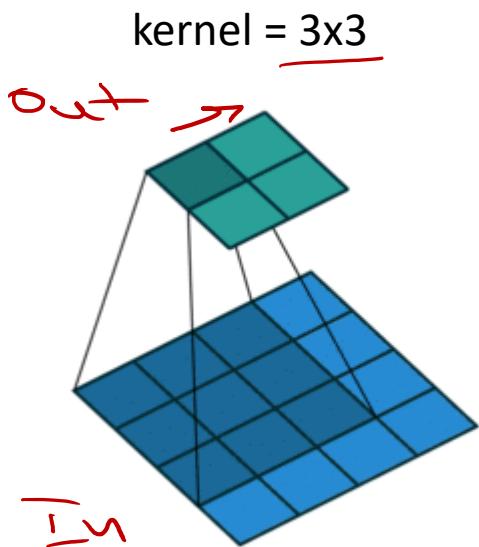
Активационная функция



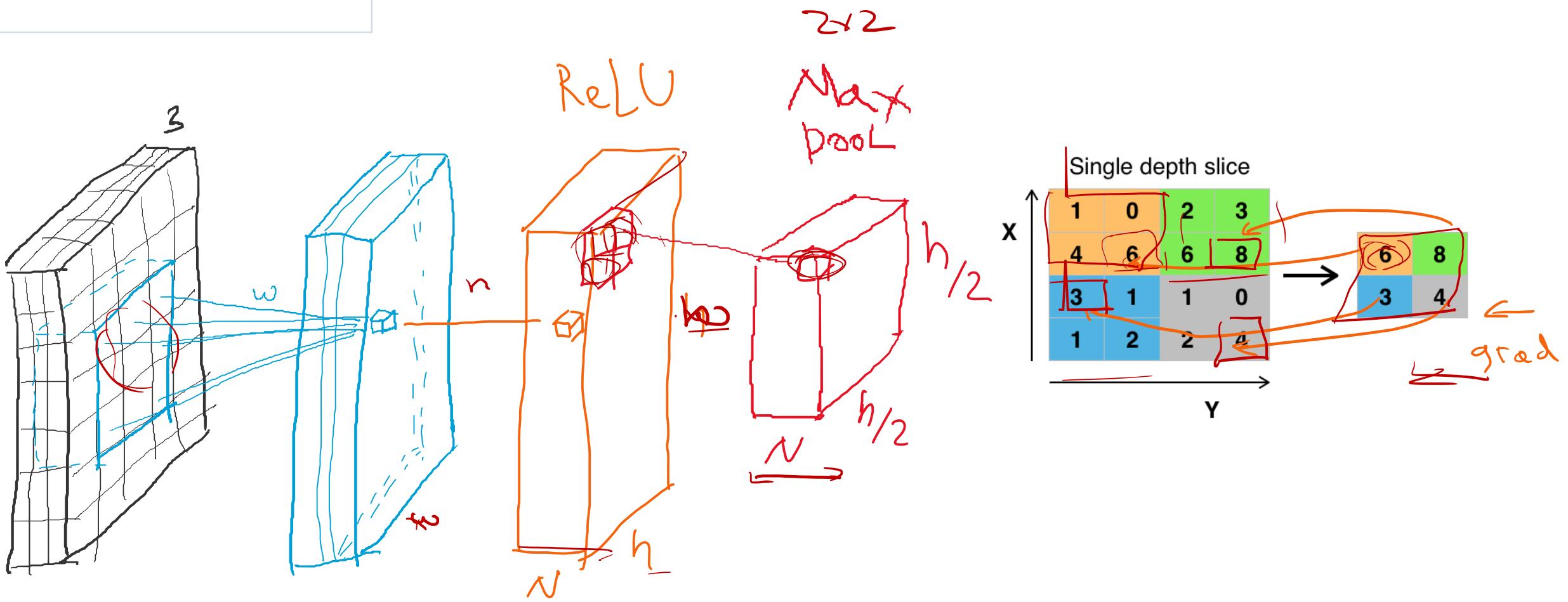
Несколько слоев



Дополнение и шаг Padding and stride

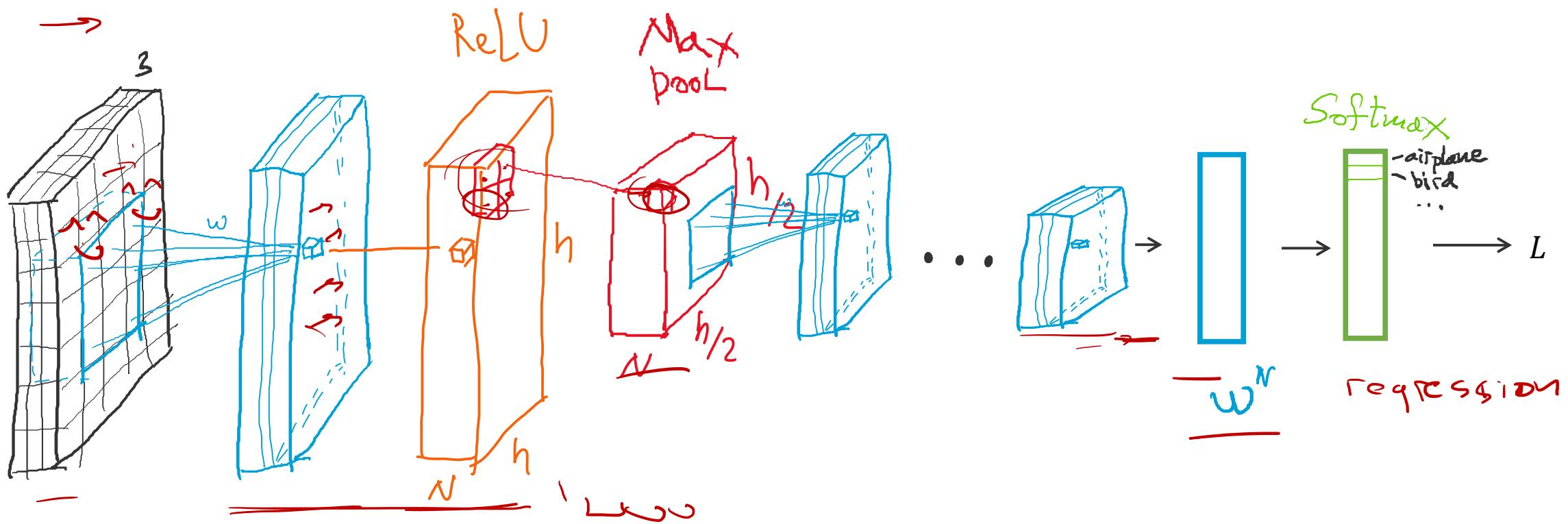


Pooling layer



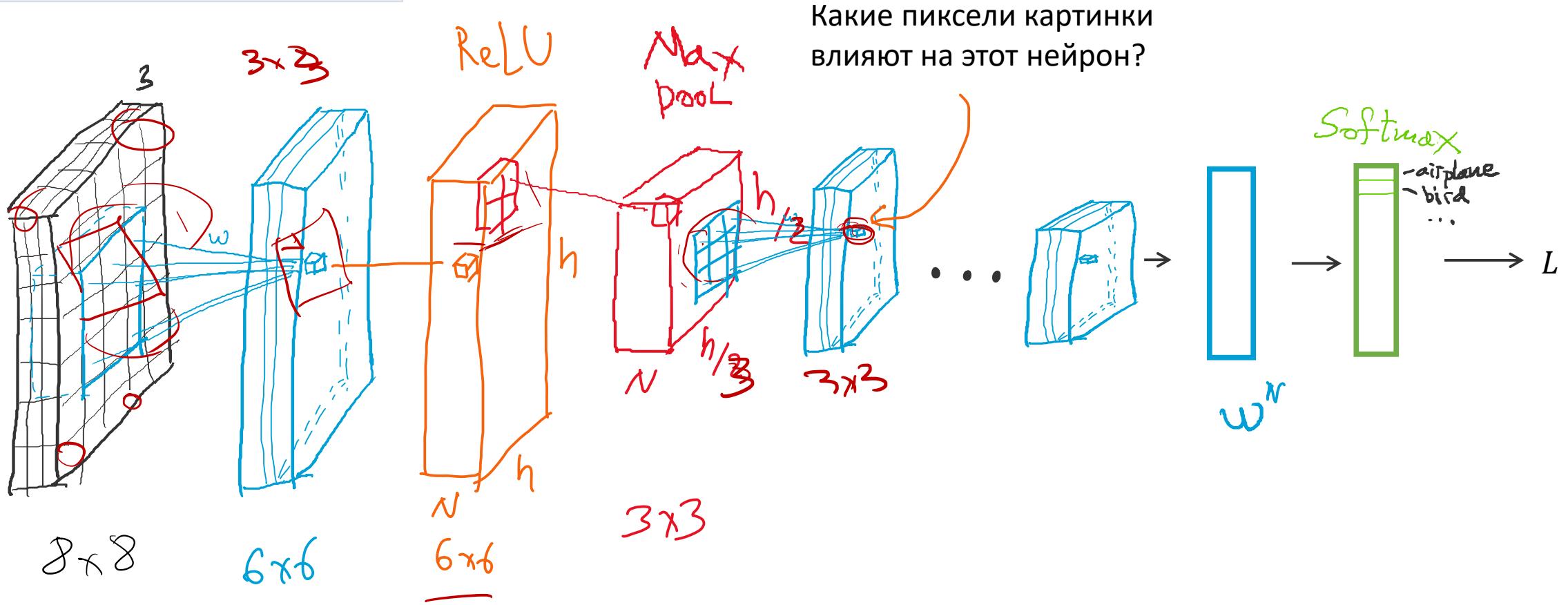
Сверточная нейронная сеть

Convolutional neural network



Рецептивное поле

Receptive field



FINALLY!!!



WE HAVE POWER!

LeNet'98

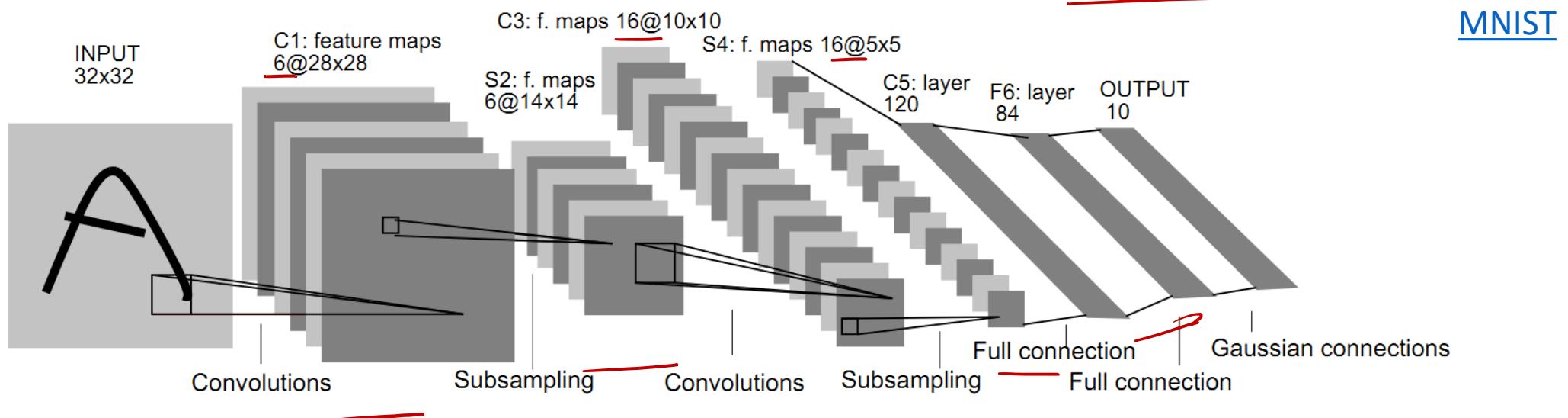


Fig. 2. Architecture of LeNet-5, a Convolutional Neural Network, here for digits recognition. Each plane is a feature map, i.e. a set of units whose weights are constrained to be identical.

IMAGENET

1000 классов
1M картинок



Large Scale Visual Recognition Challenge (ILSVRC)

1000 synsets for Object classification/localization

[kit fox, *Vulpes macrotis*](#)

[English setter](#)

[Australian terrier](#)

[grey whale, gray whale, devilfish, *Eschrichtius gibbosus*, *Eschrichtius robustus*](#)

[lesser panda, red panda, panda, bear cat, cat bear, *Ailurus fulgens*](#)

[Egyptian cat](#)

[ibex, *Capra ibex*](#)

[Persian cat](#)

[cougar, puma, catamount, mountain lion, painter, panther, *Felis concolor*](#)

[gazelle](#)

[porcupine, hedgehog](#)

[sea lion](#)

[badger](#)

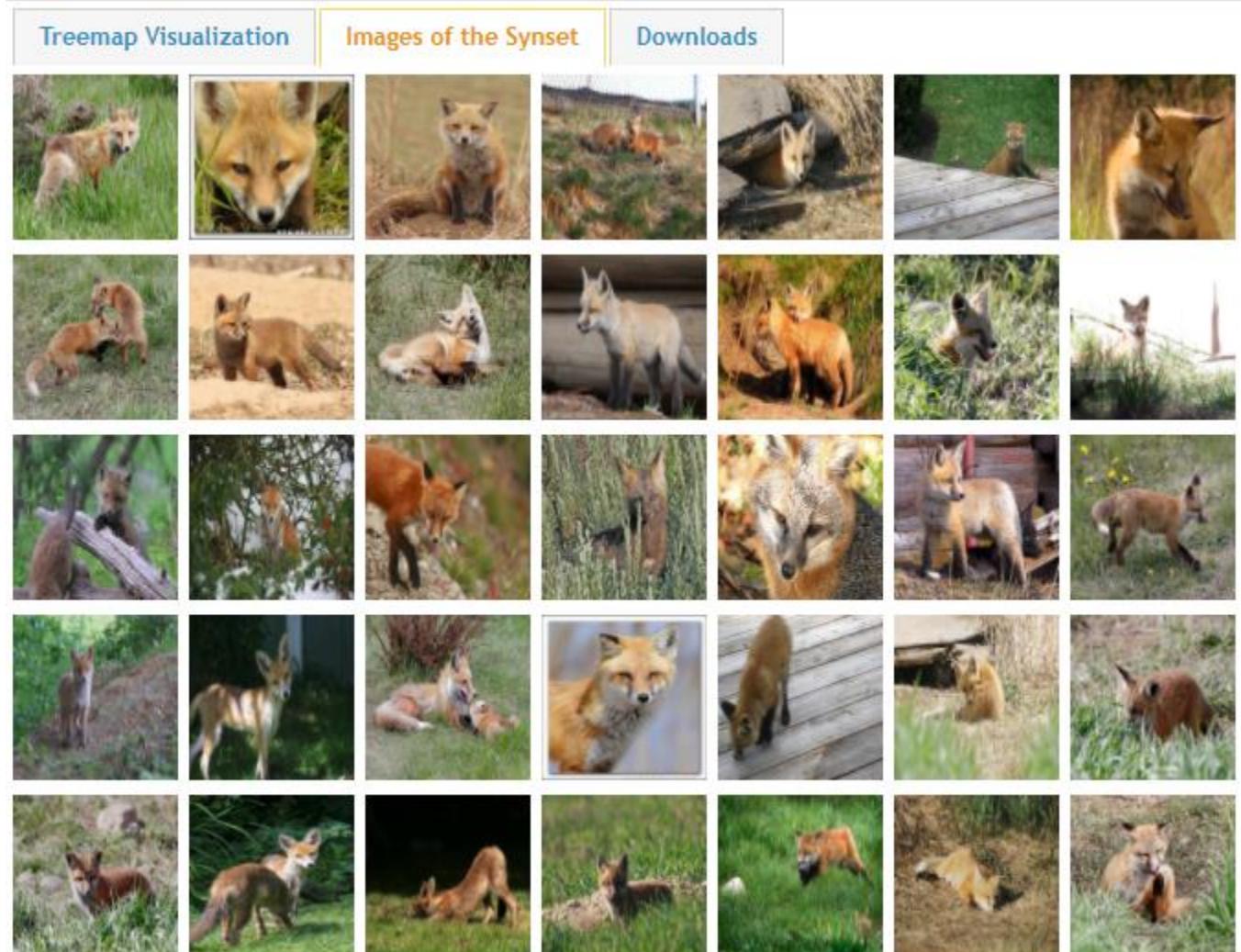
[Great Dane](#)

[Scottish deerhound, deerhound](#)

[killer whale, killer, orca, grampus, sea wolf, *Orcinus orca*](#)

[mink](#)

[African elephant, *Loxodonta africana*](#)



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lesser panda, red panda, panda, bear cat, cat bear, *Ailurus fulgens*

Egyptian cat

ibex, *Capra ibex*

Persian cat

cougar, puma, catamount, mountain lion, painter, panther, *Felis concolor*

gazelle

porcupine, hedgehog

sea lion

badger

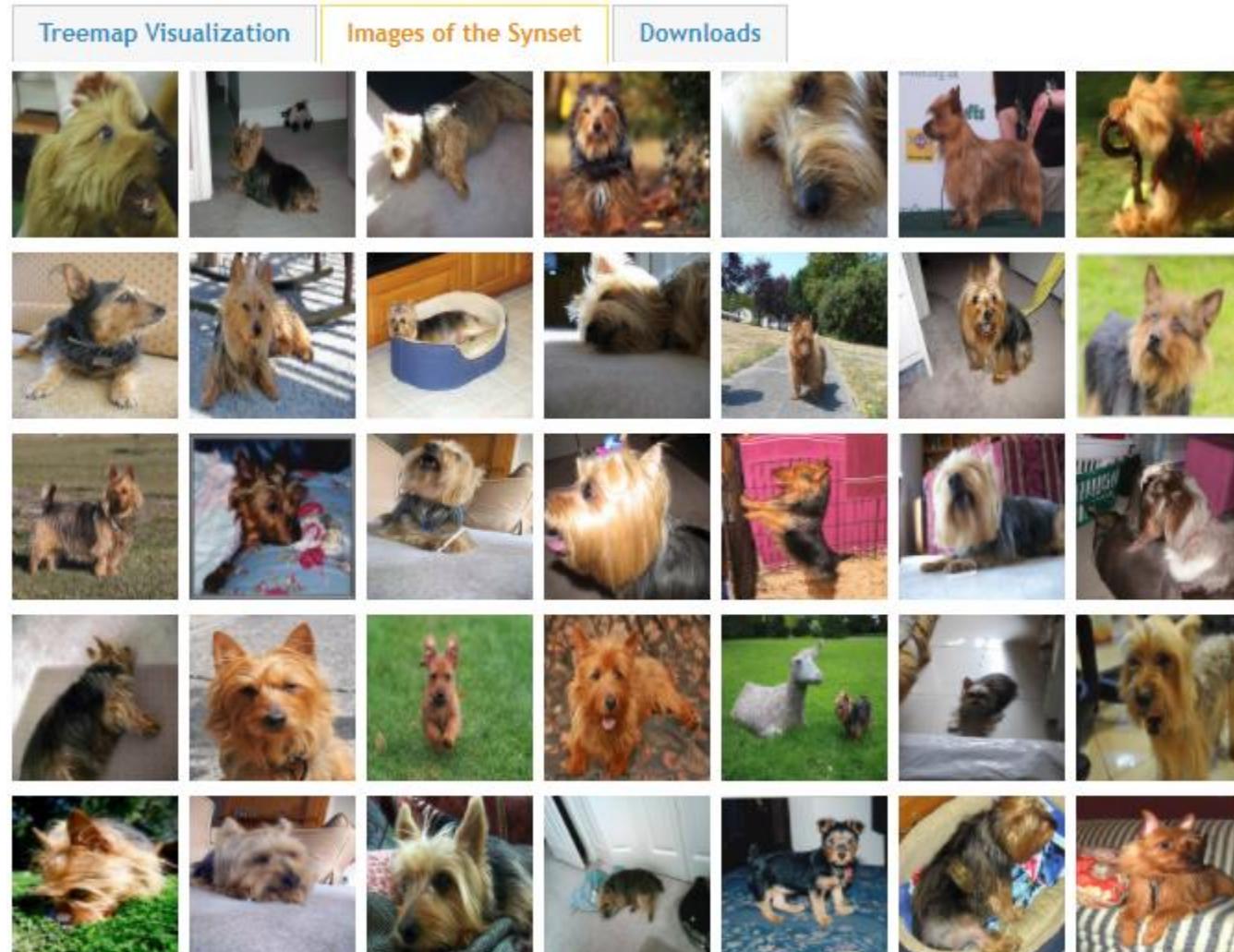
Great Dane

Scottish deerhound, deerhound

killer whale, killer, orca, grampus, sea wolf, *Orcinus orca*

mink

African elephant, *Loxodonta africana*



Large Scale Visual Recognition Challenge (ILSVRC)

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[grey whale, gray whale, devilfish, *Eschrichtius gibbosus*, *Eschrichtius robustus*](#)

[lesser panda, red panda, panda, bear cat, cat bear, *Ailurus fulgens*](#)

[Egyptian cat](#)

[ibex, *Capra ibex*](#)

[Persian cat](#)

[cougar, puma, catamount, mountain lion, painter, panther, *Felis concolor*](#)

[gazelle](#)

[porcupine, hedgehog](#)

[sea lion](#)

[badger](#)

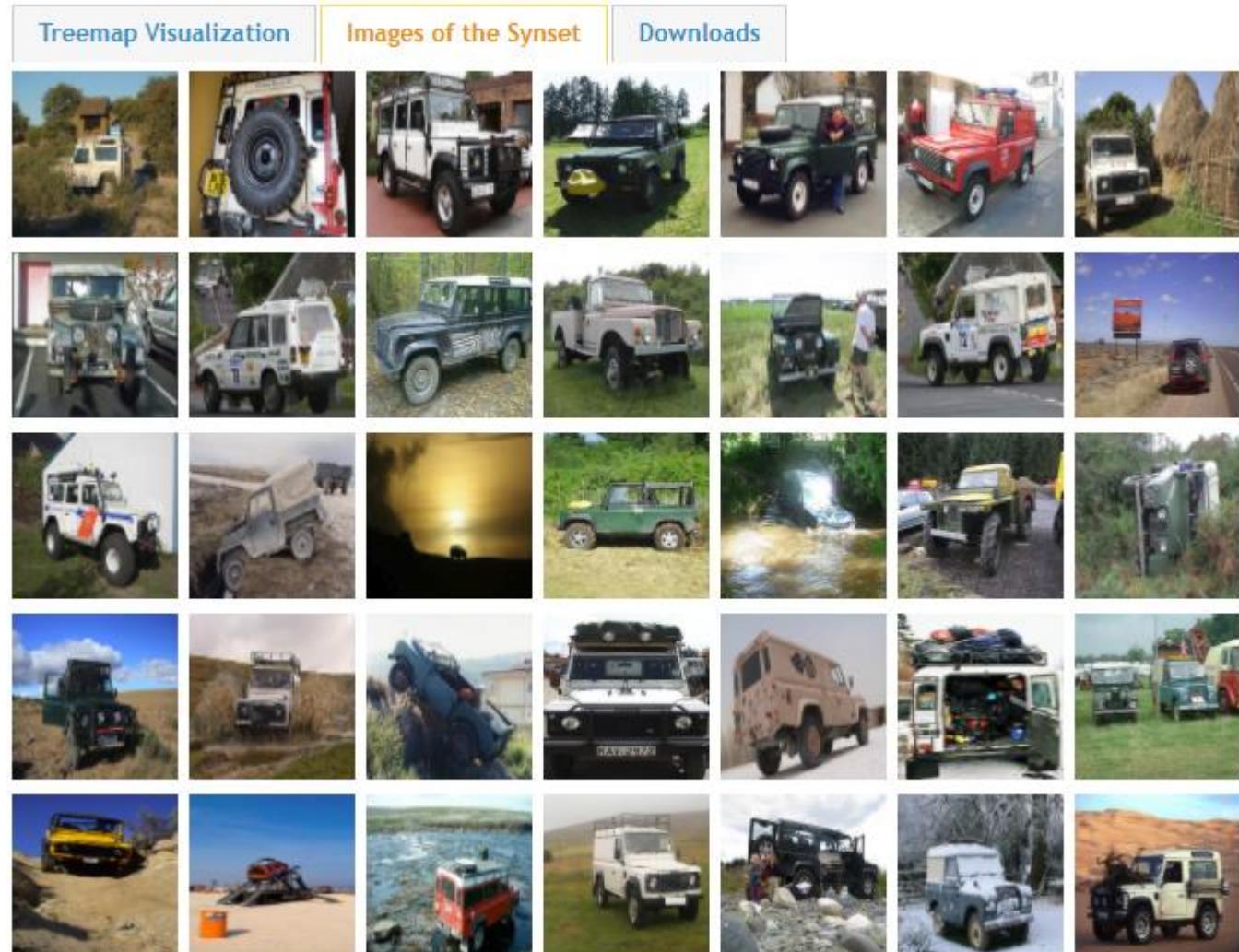
[Great Dane](#)

[Scottish deerhound, deerhound](#)

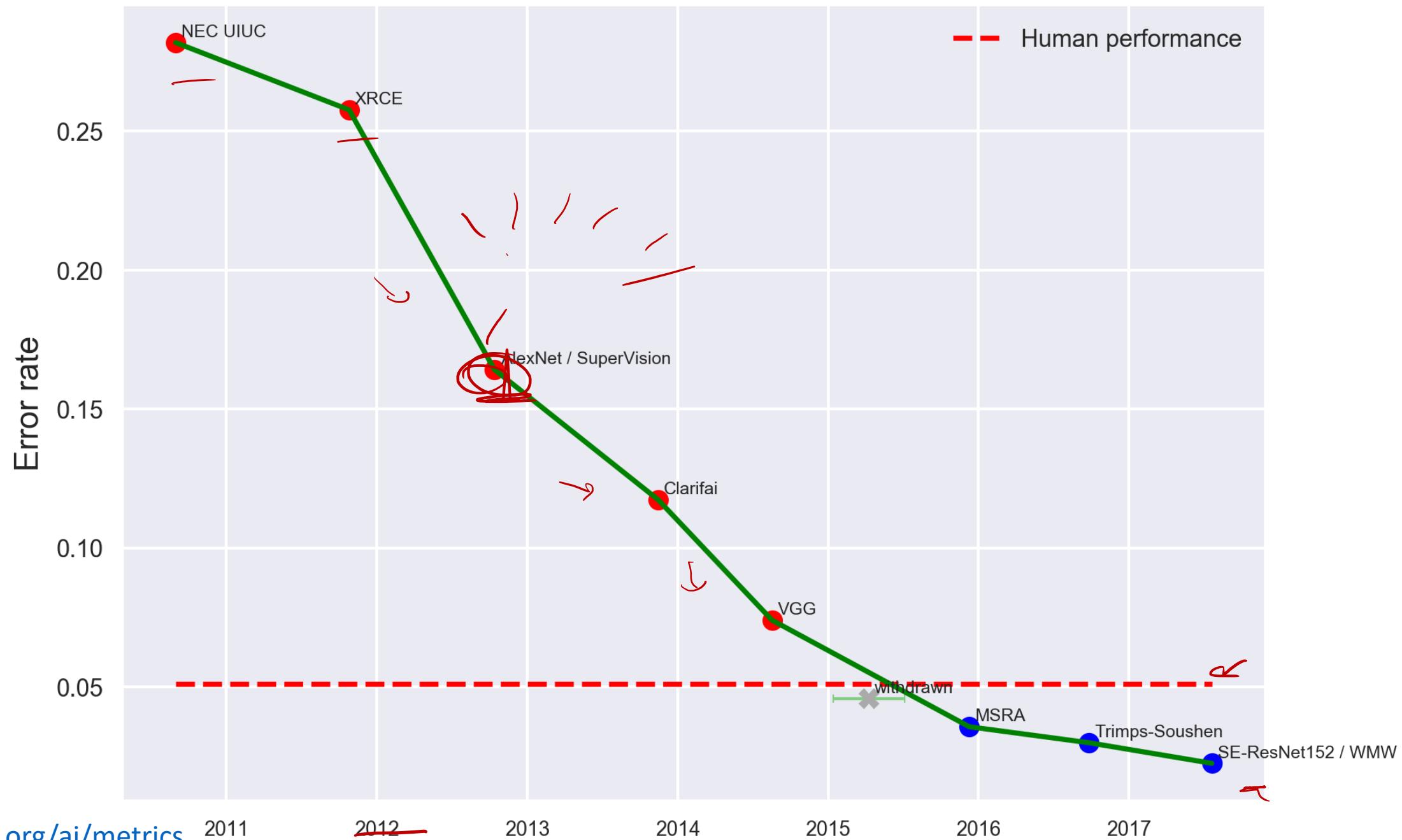
[killer whale, killer, orca, grampus, sea wolf, *Orcinus orca*](#)

[mink](#)

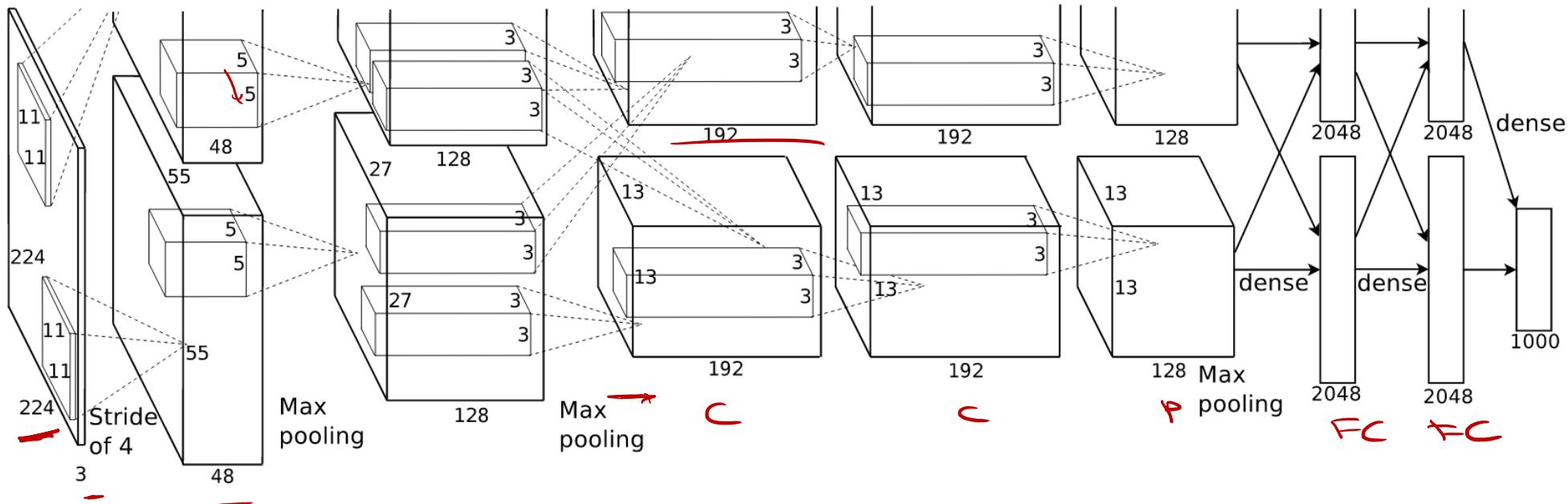
[African elephant, *Loxodonta africana*](#)



Imagenet Image Recognition



AlexNet'12

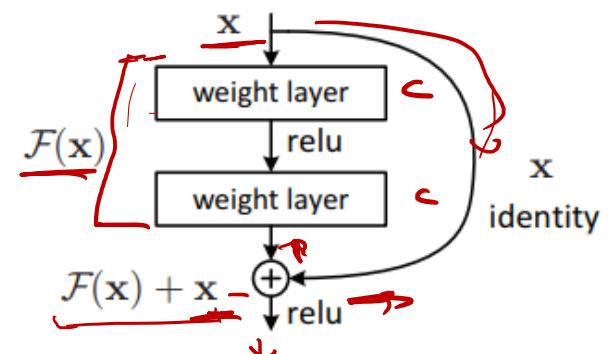
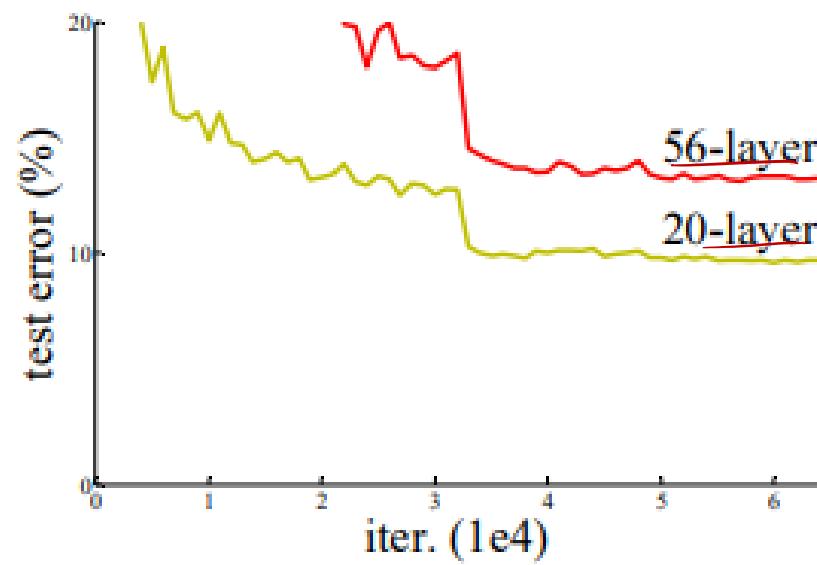
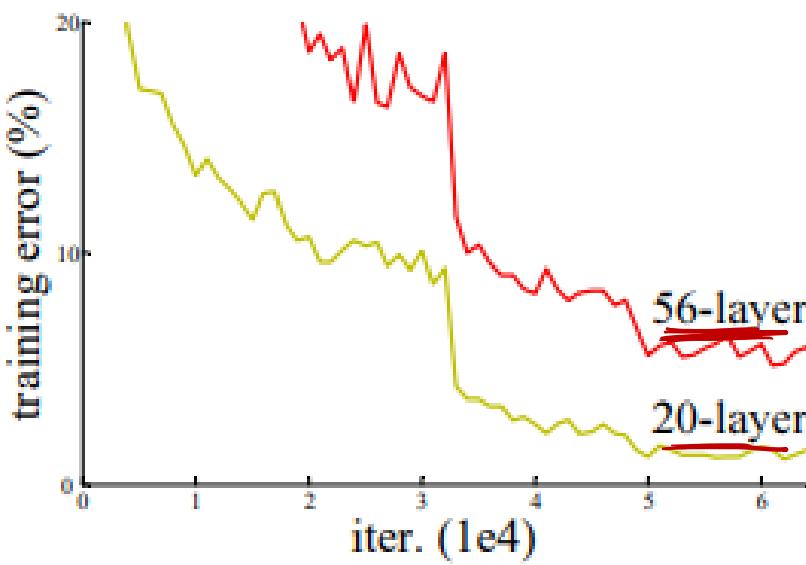


VGG'14

| ConvNet Configuration | | | | | |
|-------------------------------------|-----------------------------|-------------------------------|--|--|--|
| A | A-LRN | B | C | D | E |
| 11 weight layers | 11 weight layers | 13 weight layers | 16 weight layers | 16 weight layers | 19 weight layers |
| input (224×224 RGB image) | | | | | |
| conv3-64 LRN | conv3-64 conv3-64 | conv3-64 conv3-64 | conv3-64 conv3-64 | conv3-64 conv3-64 | conv3-64 conv3-64 |
| maxpool | | | | | |
| conv3-128 | conv3-128 | conv3-128 conv3-128 | conv3-128 conv3-128 | conv3-128 conv3-128 | conv3-128 conv3-128 |
| maxpool | | | | | |
| conv3-256 conv3-256 | conv3-256 conv3-256 | conv3-256 conv3-256 | conv3-256 conv3-256 conv1-256 | conv3-256 conv3-256 conv3-256 | conv3-256 conv3-256 conv3-256 |
| maxpool | | | | | |
| conv3-512 conv3-512 | conv3-512 conv3-512 | conv3-512 conv3-512 | conv3-512 conv3-512 conv1-512 | conv3-512 conv3-512 conv3-512 | conv3-512 conv3-512 conv3-512 |
| maxpool | | | | | |
| conv3-512 conv3-512 | conv3-512 conv3-512 | conv3-512 conv3-512 | conv3-512 conv3-512 conv1-512 | conv3-512 conv3-512 conv3-512 | conv3-512 conv3-512 conv3-512 |
| maxpool | | | | | |
| FC-4096 | | | | | |
| FC-4096 | | | | | |
| FC-1000 | | | | | |
| soft-max | | | | | |

6.8% top5 error
~140M параметров

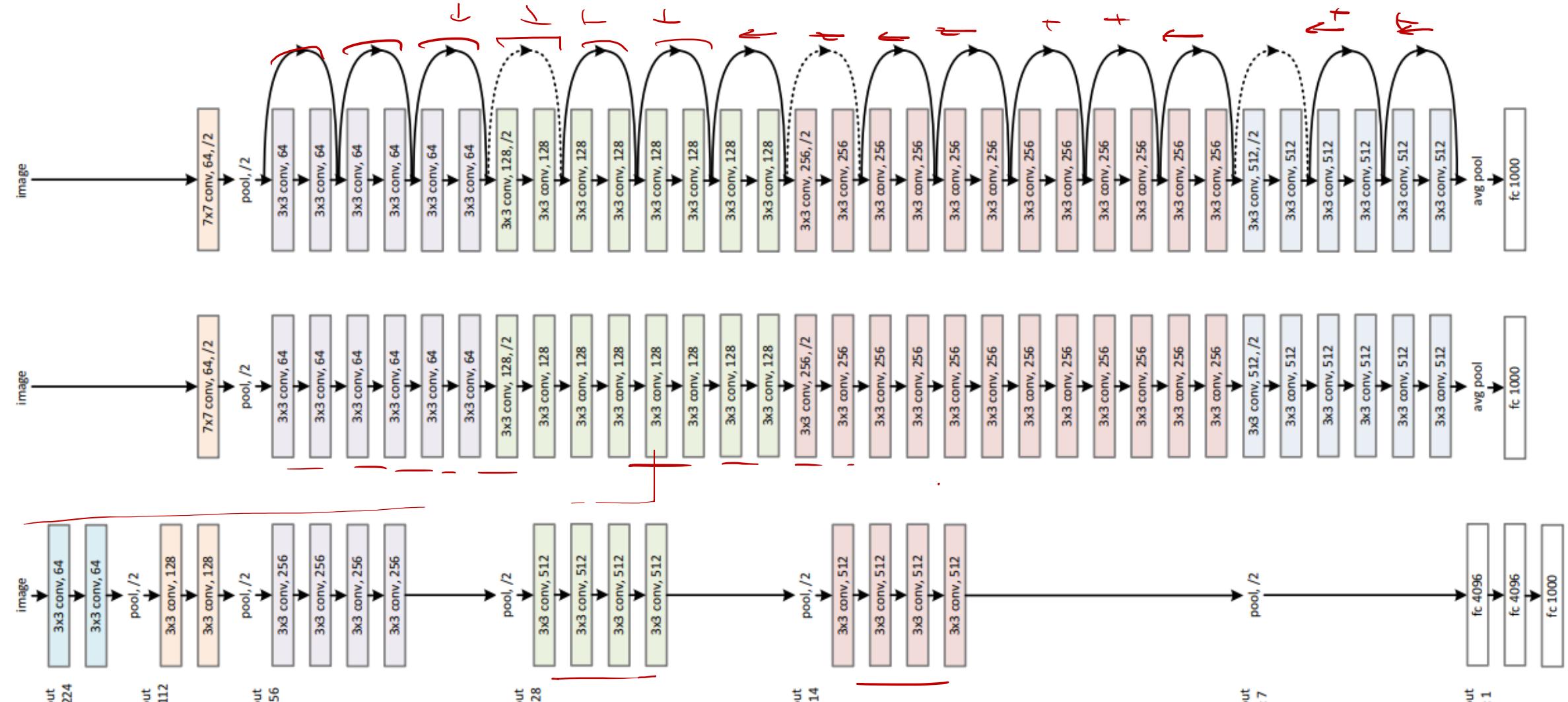
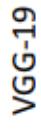
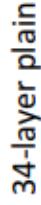
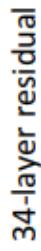
ResNet'15



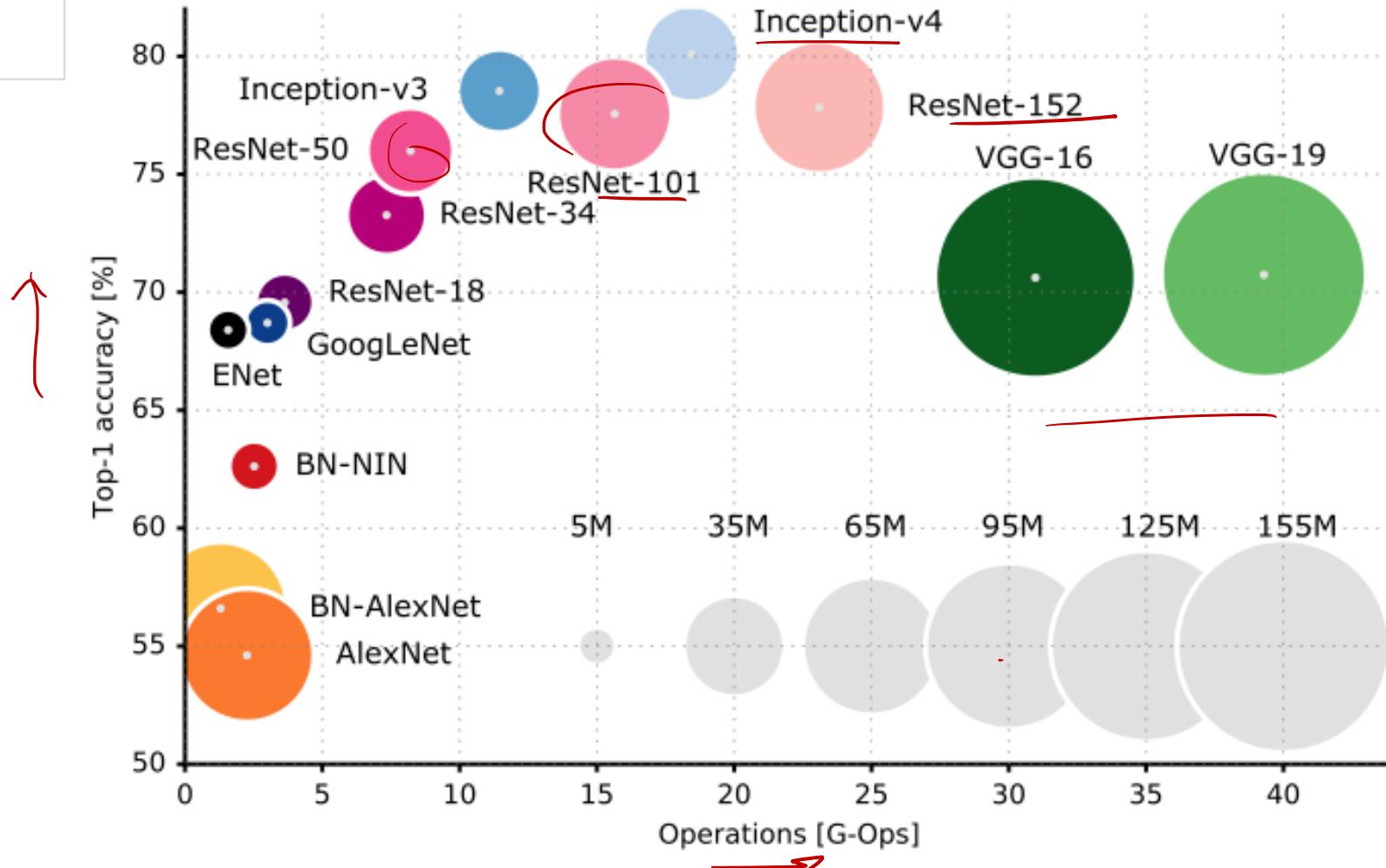
ResNet'15

ResNet Ensemble

3.57% top5 error

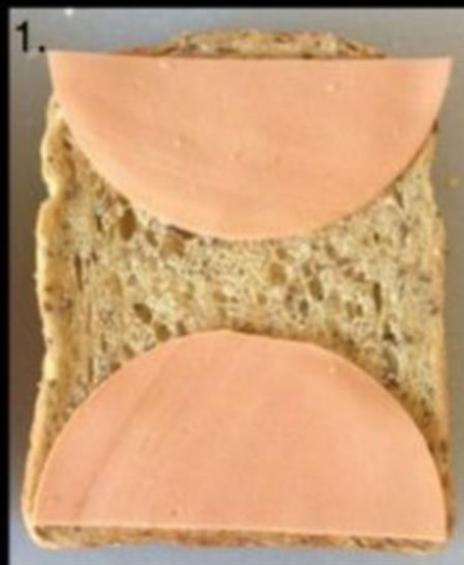
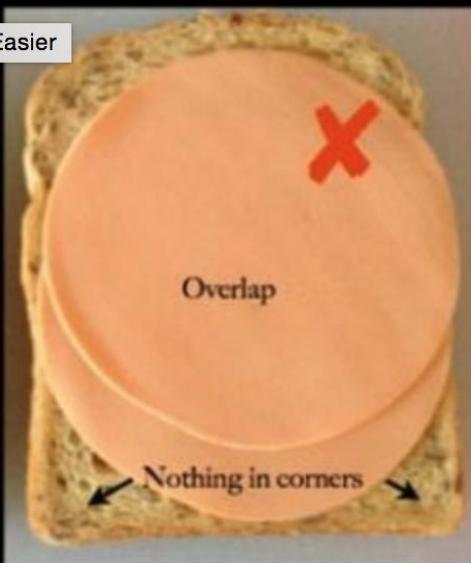


Все архитектуры на одной картинке

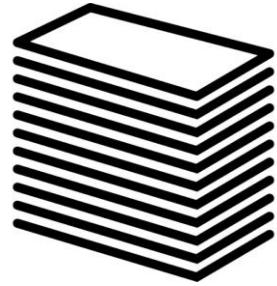


20 Practical Tricks Which Will Make Your Life Easier

Good Sandwich Guide

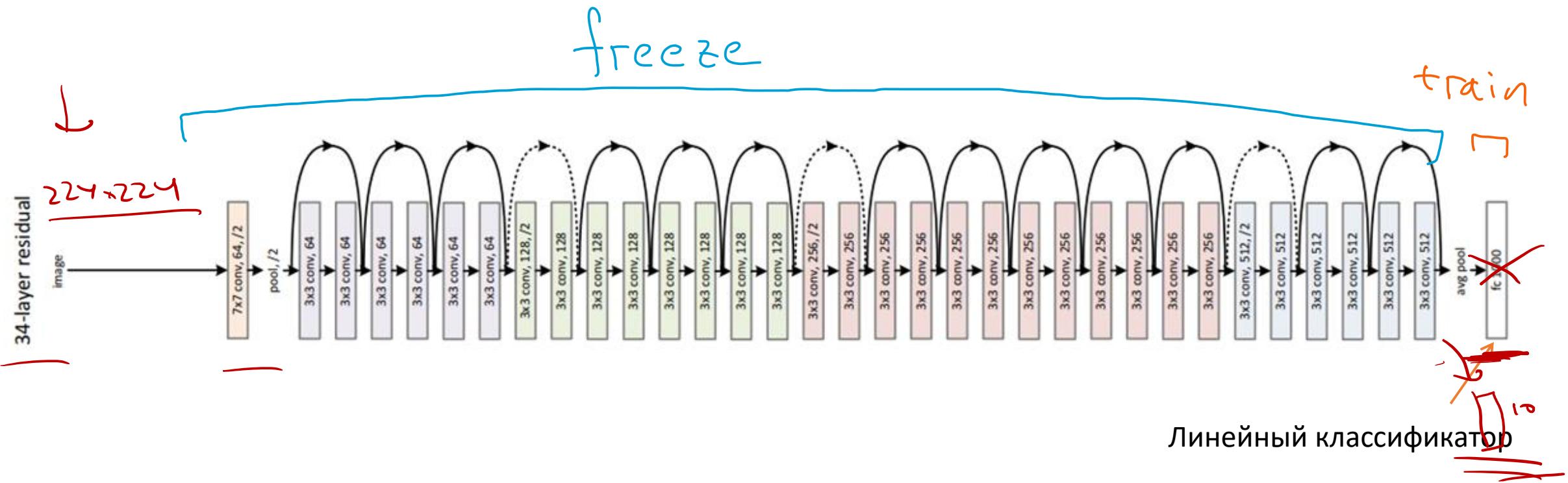


Transfer learning

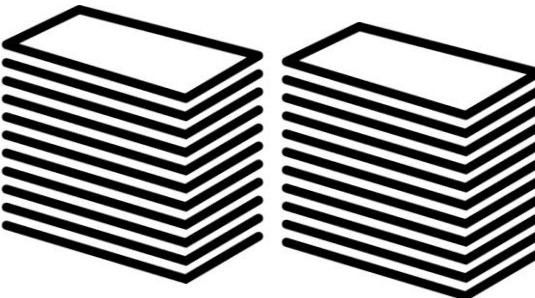


Мало данных (~10-100 картинок)

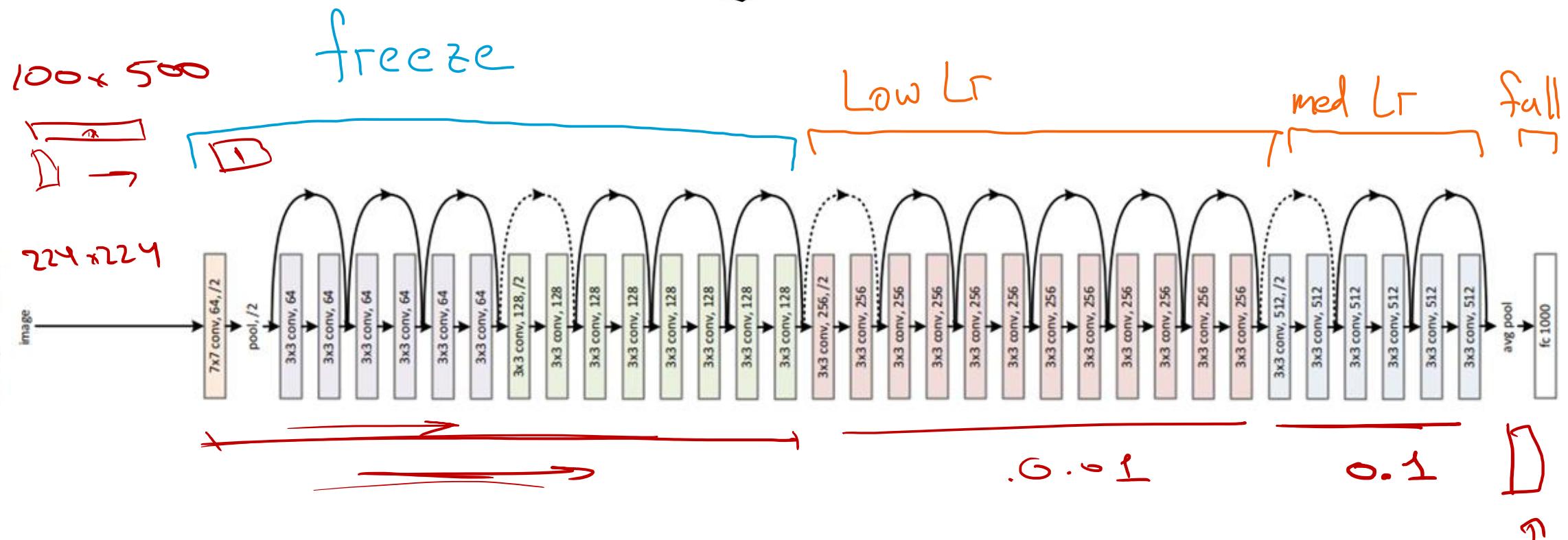
ResNet 34
101



Transfer learning



Чуть больше данных (~1000+ картинок)



The data says we need more data.



som
ee
cards
user card

Виды аугментации

Отражение



Смещение



Изменение цвета

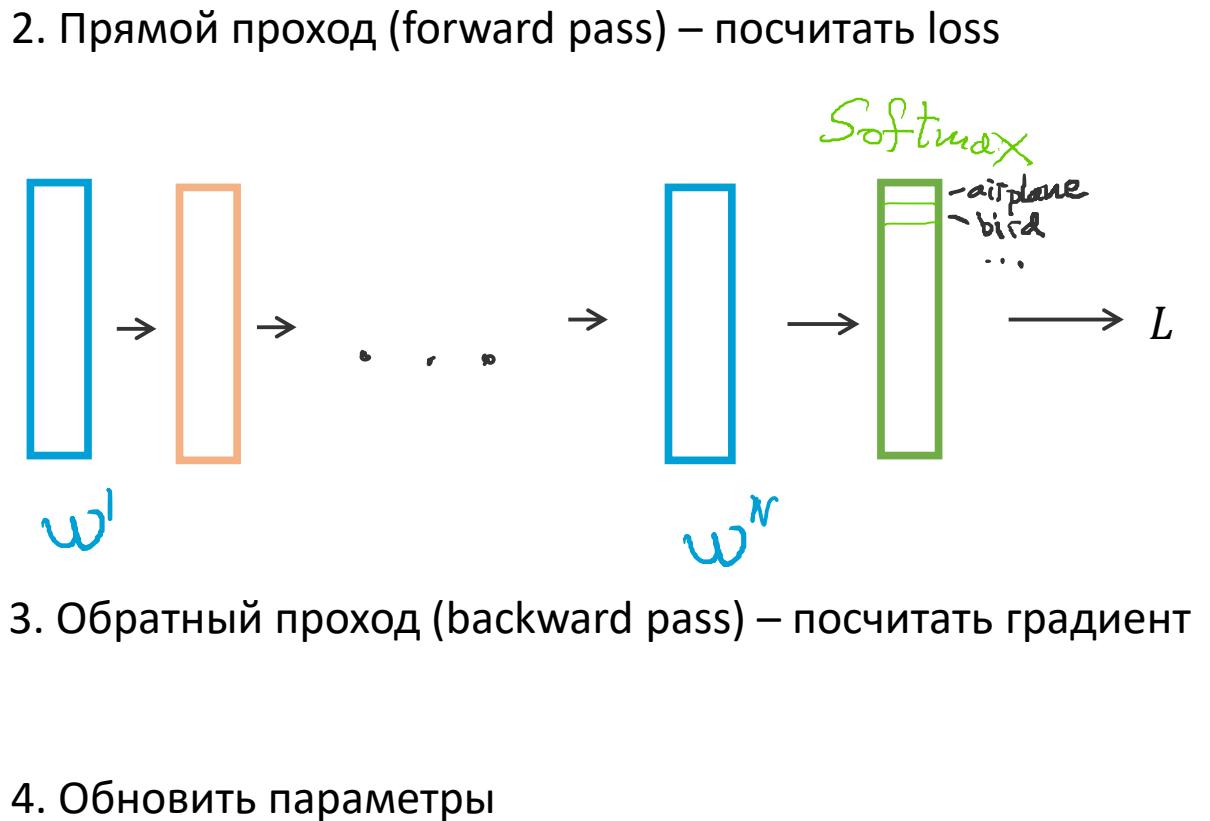
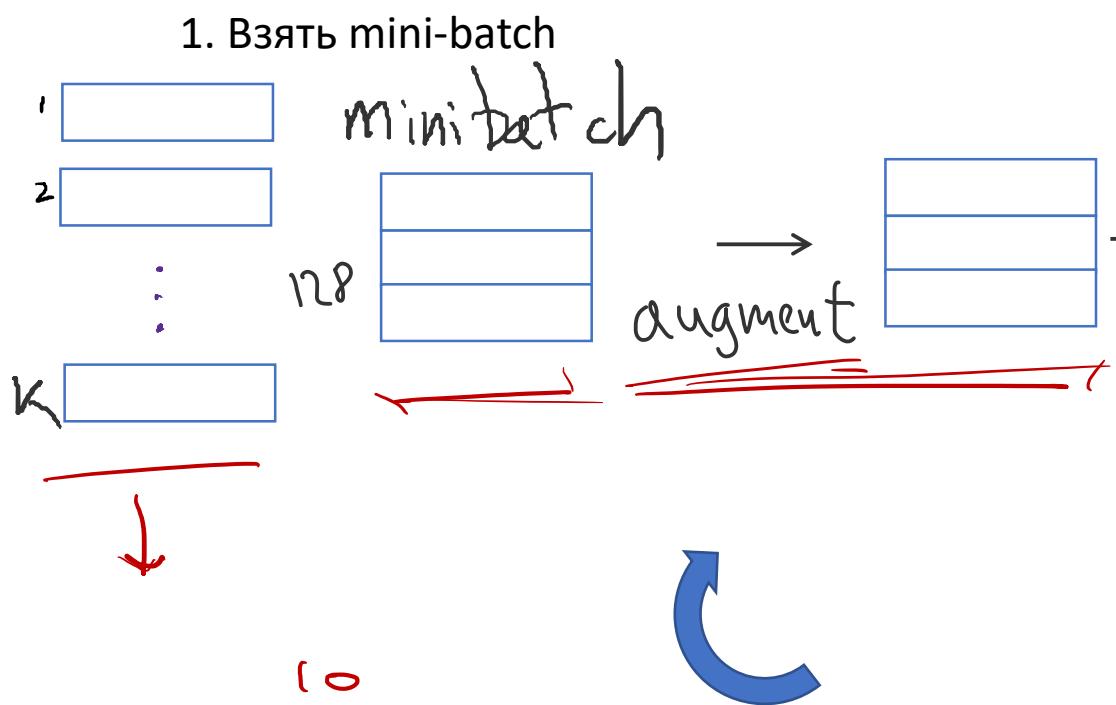


Повороты
Наклоны
...
Креатив

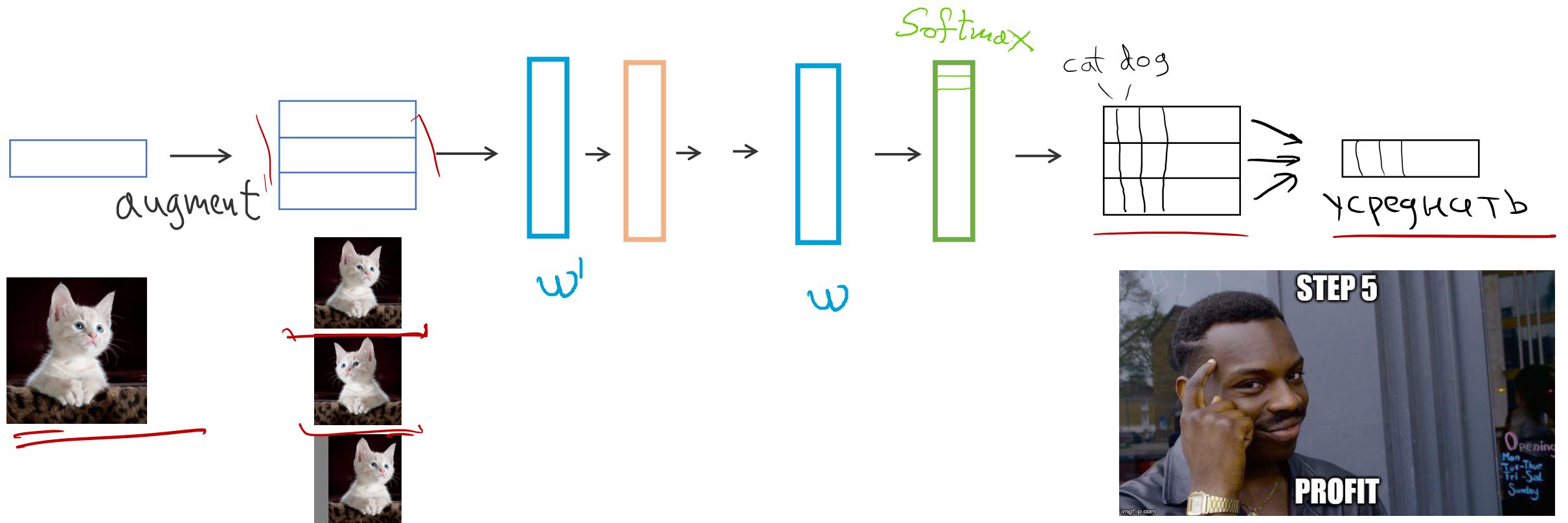
aug_image = image * a + b

<https://github.com/albu/albumations>

Online augmentation



Test time augmentation (TTA)



I HAZ A QUESTION

